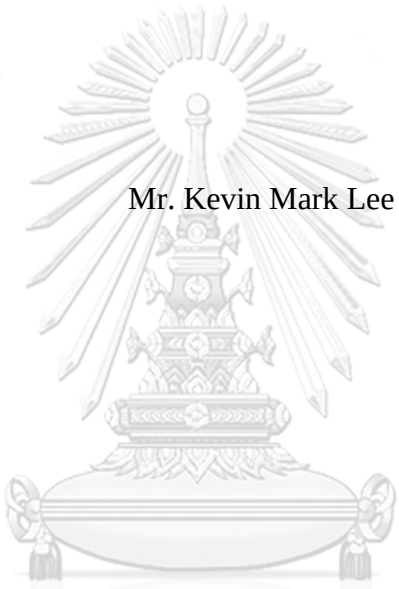
A NEW MULTILATERAL ELECTRICITY TRADING MODEL FOR ASEAN

Mr. Kevin Mark Lee



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Thesis Title	A NEW MULTILATERAL ELECTRICITY TRADING MODEL FOR ASEAN
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เควิน มาร์ค ลี : ตัวแบบใหม่ของการค้ากระแสไฟฟ้าพหุภาคีสำหรับอาเซียน (A NEW MULTILATERAL ELECTRICITY TRADING MODEL FOR ASEAN) อ.ที่ปรึกษาวิทยานิพนธ์หลัก: รศ. ดร. วิทยา สุจริตธนารักษ์, อ.ที่ปรึกษาวิทยานิพนธ์ร่วม: ดร.โสภิตสุดา ทองโสภิต, หน้า.

ระบบเชื่อมโยงไฟฟ้าอาเซียน ได้ก่อตั้งขึ้นในปี 1997 เพื่อเป็นแนวทางในการรักษาความมั่นคงด้านพลังงานในภูมิภาคเอเชียตะวันออกเฉียงใต้อย่างยั่งยืน ในช่วง 2 ทศวรรษที่ผ่านมา โครงการระบบเชื่อมโยงไฟฟ้าอาเซียนเผชิญกับความท้าทายที่สำคัญต่อการพัฒนาทางกายภาพและโครงสร้างพื้นฐาน สิ่งต่างๆ เหล่านี้เป็นจริงได้ยากเนื่องจากภาพสังคมการเมือง การริเริ่มแลกเปลี่ยนกระแสไฟฟ้า เป็นข้อเสนอเบื้องต้นของตลาดพลังงานภูมิภาคอาเซียน ซึ่งอาจพิสูจน์แนวทางความเป็นไปได้มากขึ้นสำหรับการบูรณาการทางด้านพลังงาน เนื่องจากไม่จำเป็นต้องมีการจำหน่ายหรือแปรรูปตลาดการไฟฟ้าในแต่ละประเทศอย่างสมบูรณ์ วิทยานิพนธ์นี้ได้วิเคราะห์การแลกเปลี่ยนพลังงานไฟฟ้าในแต่ละภูมิภาคที่ตั้งอยู่ทั่วโลกเพื่อหาบทเรียน โครงสร้าง และวิธีการที่เป็นประโยชน์ ซึ่งจะสามารถนำไปประยุกต์ใช้ร่วมกับแนวคิดและการดำเนินงานของ AEE ได้

สาขาวิชา เอเชียตะวันออกเฉียงใต้ศึกษา ลายมือชื่อนิสิต .....

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KEVIN MARK LEE: A NEW MULTILATERAL ELECTRICITY TRADING MODEL FOR ASEAN. ADVISOR: ASSOC. PROF. WITHAYA SUCHARITHANARUGSE, Ph.D., CO-ADVISOR: SOPITSUDA TONGSOPIT, Ph.D., pp.

The ASEAN Power Grid (APG) was initiated in 1997 as a means to achieve energy security in Southeast Asia in a sustainable manner. Two decades on, the APG project faces significant challenges to the development of both physical and institutional infrastructure. Many of these cannot be easily addressed due to the socio-political realities of the region. The ASEAN electricity exchange initiative (AEE), a proposal by the ASEAN Energy Market Initiative, may prove to be a more feasible approach for regional power sector integration, as it does not require complete domestic electricity market unbundling or privatization. This thesis analyzes regional electricity exchanges that have been set up around the world in order to derive useful lessons, structures, and approaches that are applicable for the AEE's conception and implementation.

Field of Study: Southeast Asian Studies Student's Signature .....
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Chapter 1:
Introduction

Electricity is the lifeblood of every modern society – it is the fundamental input for all economic and social activity; hence, governments around the world have emphasized the need for *electricity security*. This is especially relevant for an emerging region like Southeast Asia, where the availability of sufficient supplies of electricity at stable prices has a direct impact on both economic and social development in the region.

Within this context, ASEAN has identified the ASEAN Power Grid as a flagship project within the ASEAN economic cooperation (AEC) framework. The APG initiative seeks to create a unified electricity grid spanning the entire Southeast Asian region; this would enable ASEAN to take advantage of complementarity of domestic electricity load curves among member states, as well as facilitate the efficient utilization of ASEAN's wealth of diverse (but unevenly distributed) electricity generation resources. In this way, the APG project improves regional electricity security by reducing the need for imports of power generation fuels from outside the region; while also delivering significant cost savings for ASEAN governments.

Based on the APG objectives as stated in the ASEAN Plan of Action for Energy Cooperation (APAEC) 2016 – 2025 (ACE, 2015), this thesis breaks down ASEAN's approach to APG implementation into three main phases:[1]

Phase I: Deepen physical infrastructure integration through the construction of cross-border power transmission interconnections

[1] The phases of ASEAN Power Grid implementation are not chronologically distinct. The development of bilateral interconnections is projected to continue well into the future, but the APG consultative committee (APGCC) has set targets for the achievement of multilateral trading between at least three ASEAN countries by 2018, and has also begun to explore the creation of an ASEAN electricity exchange (AEE). All of these actions are being pursued concurrently.

Phase II: Implement multilateral electricity trading in one of ASEAN's sub-regions

Phase III: Establish a fully-integrated regional grid system

Since the APG's inception in 1997, it has already seen substantial progress in terms of physical cross-border power infrastructure development (Finenko, 2016), which has facilitated bilateral power flows within the region. While the physical infrastructure expansions underlying the APG project will continue well beyond 2020, ASEAN is also beginning to embark on the second phase of APG development – the AEC Blueprint 2025 has set the target of achieving multilateral electricity trade in at least one sub-region by 2018 (ASEAN, 2015). Here, it should be noted that the mechanisms for multilateral power trade have not been explicitly defined. Likewise, while the APG envisions the establishment of a "total integrated regional system" to enhance cross-border electricity trade (ACE, 2015), ASEAN's documents have not been explicit about whether this would involve the creation of a competitive regional power exchange.

1.1 Significance and Objectives

This M.A. thesis aims to make a small contribution to the APG project, by discussing how the creation of a regional power exchange could be a new – and perhaps more feasible – approach to deepening power sector integration in Southeast Asia.

The APG will need to overcome significant financing and governance barriers that impede the implementation of the project's first two phases. A wide range of solutions have been proposed in the existing academic literature to address these challenges. While this provides a useful theoretical framework for the creation of a regional power market, such policy recommendations must ultimately be adapted to the unique socio-political realities of each region. This thesis argues that many of the proposed solutions may not be feasible for implementation in ASEAN, based on a more nuanced understanding of the region.

In May 2016, the Heads of ASEAN Power Utilities/Authorities (HAPUA) began to explore the creation a regional power exchange as a new approach to implementing the APG initiative – a joint HAPUA-ASEAN Energy Market Initiative (AEMI) workshop was conducted, which included presentations from consultants of successful regional electricity trading models such as the Nord Pool and the Southern Africa Power Pool. This thesis builds on the good work that the AEMI has already achieved.

The ASEAN Electricity Exchange (AEE) could be developed concurrently with the APG's first two phases, as an alternative but complementary pathway to deepening electricity market integration in the region. As HAPUA is in the midst of conducting feasibility studies for the AEE, there are no available details about its implementation process, and how it will function.

Fortunately, Southeast Asia is not the first region to have embarked on such regional power sector integration projects; some of these projects in different parts of the world have undoubtedly faced similar challenges to those of the APG, and have addressed them with varying degrees of success.

Hence, the objective of this M.A. thesis is to:

(1) Evaluate how the AEE might be an effective approach to APG implementation, considering the feasibility challenges faced by the first two phases.

(2) Identify potential lessons that may be relevant for the creation of the AEE, based on the experiences of other regional power sector integration projects around the globe.

1.2 Methodology

The primary methodology of this study is a qualitative analysis of regional power sector integration projects around the world. Research for this analysis is based on secondary sources, which include: reports and statistics from public

agencies and international organizations, academic research, as well as industry reports. Lessons will be drawn from the experiences of other regions in setting up their respective regional electricity markets.

1.3 Hypothesis

This study's hypothesis is that no single model can directly be applied to Southeast Asia, due to the different socio-political contexts in each region. However, certain features of different models around the world have proven to be effective for the purposes of creating a regional electricity market. Hence, the APG project could benefit from the experience that has already been accrued by other regional power systems under the study.

1.4 Thesis Outline

Chapter 2 of this thesis first provides the background of the APG project – detailing the historical development of the initiative, its rationale, as well as the APG's current status of implementation – including the challenges faced by the first two phases of the APG project. **Chapter 3** delves into these challenges in greater depth, and explains the policy recommendations proposed in the existing literature. The second half of the chapter then evaluates the feasibility of implementing these solutions, based on the socio-political realities in Southeast Asia.

Chapter 4 explains the ASEAN Electricity Exchange initiative as proposed by HAPUA/AEMI, discussing how it could be a viable approach to furthering market integration within the APG framework – by addressing or circumventing the feasibility issues mentioned in the third chapter. Chapters 5 and 6 then delve into the existing academic literature on regional electricity markets around the globe, seeking out potential lessons for ASEAN's own regional initiative.

Chapter 5 provides some contextual background for the comparative analysis conducted in Chapter 6, utilizing the existing literature on regional electricity markets around the globe. Similar comparative studies have previously been conducted – given the wealth of expertise, experience, resources that many of these research projects have employed, this thesis does not attempt to reinvent the wheel by replicating the research process. Instead, it draws on the findings and conclusions reached by the existing academic literature. The most comprehensive of these studies are projects by the World Bank and USAID, which are summarized in Chapter 5. In addition, the chapter also briefly introduces a selection of the regional power exchanges covered in this thesis. A full literature review can be found in **Appendix A: Literature Review**, which covers a wider range of academic literature.

Next, **Chapter 6** critically analyzes both positive and negative lessons from other regional power exchanges, to derive certain design elements for the AEE. These design elements include the pre-requisites for creating a competitive regional

electricity market, as well as the regional structures, trading arrangements, and implementation approaches for the market. Based on these findings, the chapter ends by suggesting a proposed framework for the AEE given the ASEAN regional context.

Finally, **Chapter 7** summarizes the main conclusions of this thesis, discussing their implications for implementation of the APG project, and suggesting some potential areas of future research.

Chapter 2:
Background of the ASEAN Power Grid

This chapter provides the contextual background for this thesis. It gives a brief historical overview of the APG's development, the rationale for the initiative, as well as its current state of implementation. As part of the analysis, it will also briefly outline some of the existing problems facing the APG project.

2.1 History of the ASEAN Power Grid

Political commitment for the APG project was formalized in 2007, with signing of the Memorandum of Understanding on the ASEAN Power Grid by ASEAN's energy ministers. In reality, however, cross-border electricity purchases in Southeast Asia began much earlier, even predating the formation of the Association of Southeast Asian Nations in 1967. The first such arrangement was initiated in 1966, with the signing of a power exchange agreement between Laos and Thailand (Severino, 1999). Similar bilateral agreements would be signed a decade later in 1978 – between Malaysia and Thailand, and Malaysia and Singapore (Shi & Malik, 2013). These arrangements would form the building blocks for the vision of a unified electricity grid in Southeast Asia.

The establishment of the Heads of Power Utilities/Authorities (HAPUA) in 1981 formalized the institutional cooperation across Southeast Asia's domestic power sectors, to promote regional electricity network integration (Severino, 1999). Since then, the political commitment to the APG project has been reaffirmed multiple times, at various levels of ASEAN government – in 1997 the APG was identified as one of the flagship programs under the ASEAN Vision 2020, which aimed to forge closer economic integration within ASEAN. In 1999, the 17th ASEAN Ministers of Energy (AMEM) meeting in Bangkok tasked HAPUA to implement the APG project under the ASEAN Plan of Action of Energy Cooperation (APAEC) 1999 – 2004 framework. This culminated in two feasibility studies, completed in 2003 and 2012

respectively, which identified 16 bilateral interconnections that were deemed crucial for the creation of a unified ASEAN grid.[2]

While the ASEAN Plan of Action on Energy Cooperation (APAEC) 2004 – 2009 focuses solely on the development of bilateral power interconnections, the next version of the APAEC (2010 – 2015) identifies three phases for APG implementation – first, creating interconnections on a cross-border bilateral basis, then gradually expanding this infrastructure to function on a sub-regional basis, before finally creating a fully-integrated grid system spanning the Southeast Asian region (ACE, 2015). 16 interconnection projects have been identified as part of three sub-regions in ASEAN; namely, the Northern sub-regional system in continental Southeast Asia, which includes Cambodia, Lao PDR, Myanmar, Thailand, and Vietnam; the Southern sub-regional system, which includes Indonesia, Malaysia, and Singapore; and the Eastern sub-regional system, consisting of Brunei Darussalam, Indonesia, Malaysia, and the Philippines (See: **Fig. 1**).

The three phases of the APG's implementation are not chronologically distinct. The construction of planned interconnections is projected to continue well beyond 2020; meanwhile, the APAEC 2016 – 2025 has laid out the objective of initiating multilateral electricity trade in one sub-region of ASEAN by 2018 (ACE, 2015). In addition, in a joint HAPUA/UNESCAP workshop in April 2017, ASEAN energy ministers have commissioned a feasibility study for the ASEAN Electricity Exchange (AEE) initiative, which would facilitate the development of a competitive regional market.

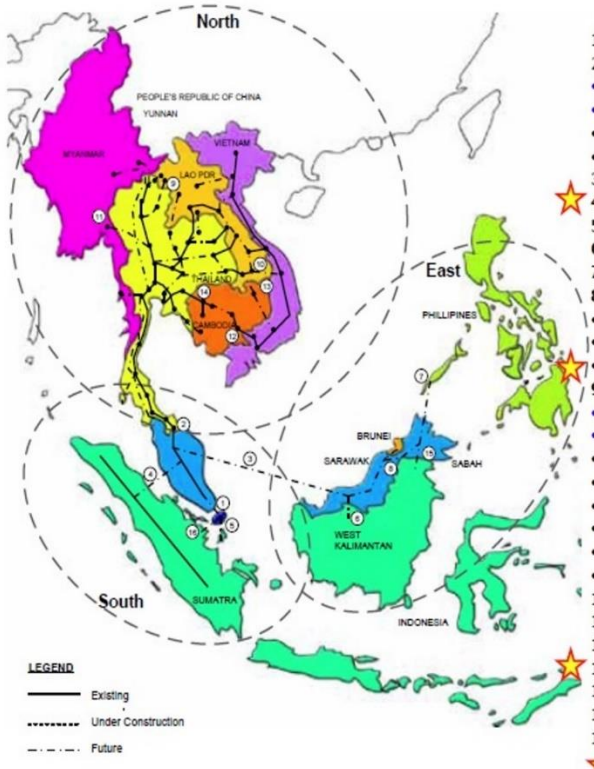
2.2 Rationale and Benefits of the ASEAN Power Grid (APG) Project

Ensuring regional electricity security is one of the stated objectives of the APG project, against the backdrop of a growing regional electricity deficit. The International Energy Agency projects that ASEAN's electricity consumption will

[2] The two feasibility studies are the ASEAN Interconnection Master Plan Studies (AIMS) I and II. These studies analyzed the technical and economic viability of the APG based on long-term power demand forecasts, identifying priority interconnection projects under the APG framework.

almost triple between 2013 and 2040 (IEA, 2015b). Meeting this rising demand will require an additional 354 GW of power generation capacity in ASEAN – more than double Southeast Asia's current installed capacity – which would cost an estimated 618 billion USD of investment (IEA, 2015a). The report

Fig. 1: ASEAN Power Grid Subregions and Crossborder Transmission Projects, 2016



		Earliest COD
1)	P.Malaysia - Singapore (New)	post 2020
2)	Thailand - P.Malaysia	
•	Sadao - Bukit Keteri	Existing
•	Khlong Ngae - Gurun	Existing
•	Su Ngai Kolok - Rantau Panjang	TBC
•	Khlong Ngae – Gurun (2nd Phase, 300MW)	TBC
3)	Sarawak - P. Malaysia	2025
4)	P.Malaysia - Sumatra	2020
5)	Batam - Singapore	2020
6)	Sarawak - West Kalimantan	2015
7)	Philippines - Sabah	2020
8)	Sarawak - Sabah – Brunei	
•	Sarawak –Sabah	2020
•	Sabah – Brunei	Not Selected
•	Sarawak – Brunei	2018
9)	Thailand - Lao PDR	
•	Roi Et 2 - Nam Theun 2	Existing
•	Sakon Nakhon 2 – Thakhek – Then Hinboun (Exp.)	Existing
•	Mae Moh 3 - Nan - Hong Sa	2015
•	Udon Thani 3- Nabong (converted to 500KV)	2019
•	Ubon Ratchathani 3 – Pakse – Xe Pian Xe Namnoy	2019
•	Khon Kaen 4 – Loei 2 – Xayaburi	2019
•	Nakhon Phanom – Thakhek	2015
•	Thailand – Lao PDR (New)	2019-2023
10)	Lao PDR - Vietnam	2016-TBC
11)	Thailand - Myanmar	2018-2026
12)	Vietnam - Cambodia (New)	TBC
13)	Lao PDR - Cambodia	2017
14)	Thailand - Cambodia (New)	post 2020
15)	East Sabah - East Kalimantan	post 2020
16)	Singapore – Sumatra	post 2020

Priority Projects

Source: ACE, 2016

also estimated the need for a further 690 billion USD of investment to expand transmission and distribution infrastructure in Southeast Asia. The need for electricity security – defined in this thesis as the stability of both electricity supply and prices – is crucial for sustained economic development in ASEAN.

The APG project aims to improve electricity security in the region by taking advantage of the diversity across ASEAN's power sectors. First, the pooling of power generation assets allows ASEAN countries to reduce the power generation capacity expansions needed to meet future domestic peak demand and reserve requirements. Since the total required capacity in any grid system is based on the system's peak

load (plus a reserve margin), interconnected systems with multiple countries that have non-coincident load curves can meet demand with fewer generating resources (APERC, 2000; IEA, 2015a). This would also have the added benefit of improving grid stability, through mutual emergency power and peak demand support; as exemplified by the Singapore-Malaysia interconnection, which has functioned since 1983 based on a net-zero monthly exchange (IEA, 2015a).

Second, through connecting ASEAN's domestic power markets, the APG facilitates greater investment in power generation projects around the region, thus, increasing regional power capacity. The profitability of power generation projects is evaluated partially based on the size of the potential market. With a regionally integrated ASEAN power market – underpinned by the APG's physical grid network – electricity generated within one jurisdiction can potentially reach domestic consumers across the region. This would positively impact the bankability of power supply projects, as potential investors begin to evaluate these projects based on regional rather than national consumer demand.

Third, the APG could increase the economic efficiency of the Southeast Asian power sector, thus potentially lowering the average price of electricity. Southeast Asia as a region has abundant and diverse energy resources, which include hydropower, oil, natural gas, and coal. However, these resources are unevenly distributed within and across ASEAN countries, which contributes to electricity price disparities that exist across different domestic markets. The creation of a regional grid would allow for cheaper power assets in one jurisdiction to displace more expensive generation in another – such efficient allocation of generation capacity and energy resources would likely lower the average cost of electricity in ASEAN (IEA, 2015a).

Overall, the APG project is expected to bring with it significant cost savings for ASEAN. The updated ASEAN Interconnection Masterplan Study (AIMS II) by HAPUA concluded that the APG project would deliver net savings for ASEAN

estimated at USD 1,872 million (ACE, 2015). Another 2015 study estimates that the cumulative cost savings of the APG could come up to $15.8 billion USD by 2050 (Matsuo et al., 2015). In addition, the collective exploitation of energy resources in ASEAN with increased private sector participation would greatly reduce the reliance on imported fuel from other regions (Ibrahim, 2014).

Non-energy security benefits

There are also significant social and institutional benefits to be reaped from electricity market integration in ASEAN, especially in terms of climate change mitigation, increased access to electricity, as well as the advancement of ASEAN institutions.

The APG could help to decarbonize Southeast Asia's power sector by increasing the penetration of renewables in ASEAN's electricity fuel mix (Ahmed et al., 2017; Li, Chang, Hoong, & Sharma, 2016). Ahmed, et al. (2017) explains that Southeast Asia's current dependence on fossil fuels to meet 74% of its energy needs is primarily due to the lack of transmission capacity that can connect the region's remotely-located renewable resources to electricity demand centers. This problem is especially significant for Singapore, which has limited capacity to develop renewable power generation. In addition, the high capital costs involved in renewable power generation projects also raises the bar for investment. The APG directly addresses these issues, through the development cross-border transmission capacity that connects renewable electricity resources to Southeast Asian markets; thereby increasing the commercial viability of these higher-risk renewable power projects.

In this way, the APG could facilitate an increased penetration of clean(er) power in ASEAN's electricity fuel mix, with gas-fired generation from Brunei, Malaysia and Indonesia displacing coal-fired generation, and hydropower from Burma and Laos helping to meet the electricity needs of other ASEAN countries (Skeer, 2014). More specifically, the Economic Research Institute for ASEAN and East

Asia forecasts that the APG would grow the share of hydropower generation in the region's fuel mix to 24% by 2035 (Kutani & Li, 2013).[3]

On a regional scale, the APG would boost ASEAN's ability to meet its climate change targets; in addition to each ASEAN member states' Intended Nationally Determined Contributions (INDCs) under the UNFCCC framework at COP 21, ASEAN as a bloc has also committed to reducing carbon emissions by 20% within 10 years, as well as increase the share of renewables in the fuel mix to 23% by 2025. However, much more than achieving these paper commitments, climate change mitigation is especially important for Southeast Asia – a region that is especially vulnerable to the impacts of climate change (Salamanca & Nguyen, 2016).

There is a case to be made that cross-border electricity trading, in facilitating the deployment of lowest-cost generation sources, may conversely lead to an increase in the use of low-cost coal for power generation. However, the empirical evidence does not support this claim within the Southeast Asian context (Wu, 2016). In addition, both renewables and coal will continue to be part of ASEAN's power generation fuel mix in the foreseeable future, which points to the importance of government policy in supporting the deployment of renewable power, while concurrently increasing coal power plant efficiency.

Apart from the environmental benefits of the APG, the project could also increase electrification rates across the region. According to the IEA, 120 million people in Southeast Asia still do not have access to electricity (IEA, 2015b). This is mostly concentrated in the rural areas, where the infrastructural costs of connecting to the national grid tend to be higher, but consumers there tend to have lower average incomes to cover these costs. By creating a regionally-integrated power grid, rural consumers in border regions could gain access to electricity through shorter cross-border power connections, rather than through the construction of

[3] There is also a need to consider the non-climate change related environmental and social impacts of hydropower development in Southeast Asia. Wu (2016) mentions that the damming of rivers for hydroelectricity can have serious environmental consequences, which could potentially lead to inter-state conflict as water systems are shared regional resources. However, the environmental, social, and political impacts of hydropower projects lie outside the scope of this research project.

transmission lines over potentially longer distances to connect to the national grid. This has been the basis for power trading arrangements between Thailand and Lao PDR since 1972 – based on the agreement, Thailand gains access to cheaper and cleaner electricity through the import of more than 2GW of hydropower, while electricity is also re-exported to remote border towns of Lao PDR which are not connected to the national grid (IEA, 2015a).

Finally, the APG would also bring significant institutional benefits for ASEAN. First, the implementation process serves as a platform to deepen regional cooperation at various levels of both industry and government. This is clearly seen from the various forums and institutions that have been created within the APG framework. Second, 'hard' infrastructure projects such as the APG and the Trans-ASEAN Gas Pipeline (TAGP) add substance to ASEAN's relatively 'soft' institutional approach. Given the common criticisms of ASEAN as a slow-moving regional organization that lacks substantial action, these physical electricity inter-connections between ASEAN countries serve as tangible proof of the outcomes of ASEAN cooperation, dialogue, and consensus. Third, the APG would also be a learning process for ASEAN member states in terms of institutional and regulatory cooperation; the experience gained from the APG initiative would positively impact the processes and outcome of other ASEAN cooperation initiatives, especially regional infrastructure projects.

2.3 Non-economic Costs of the APG project

Here, it should be noted that one of the fundamental assumption of this thesis is that the APG project provides net positive benefits for ASEAN member countries. Having said that, it is important to also recognize that there are significant social and environmental costs associated with the construction of new generation capacity projects for export and under the regional market integration framework, to a lesser extent, transmission line projects. Few studies look at these costs specifically associated with the APG project; however, there is a wealth of academic literature that analyzes cross-border power trading projects in ASEAN from an ecological or

social perspective. This is in addition to reports that discuss the non-economic costs of regional power projects on a broader, theoretical level.

For example, Simpson (2007) analyzes cross-border power projects in Thailand, Burma, and Laos, concluding that while these projects may bring net commercial benefits, they often also lead to human and environmental insecurity (Simpson, 2007). Matthews (2012) studies the specific case of "water-grabbing" in the form of Thailand's import of Laos hydropower to meet domestic electricity demand. He argues that while private Thai investors and the political elite in Laos stand to gain millions of dollars from these projects, the negative effects of damming are significant for the local community and environment – these impacts include population displacement, the loss in biodiversity, as well as the impact on fisheries and local livelihoods (Simpson, 2007).

The United Nations has also conducted a study on international electrical grid interconnections, outlining the social and environmental costs of such projects on a broader, theoretical level. According to the report, the potential social costs of grid interconnection include the potential physical separation of local groups from the resources that they use regularly, the importation of unwanted outside social influences into areas of infrastructure construction, the social impacts of export-oriented power plant construction, and the reduced incentives in power importing countries to utilize local resources, leading to increased vulnerability of these countries to electricity supply disruptions (UN, 2006). The same study also suggests that such projects could be detrimental to the environment – the potential negative impacts include air pollution, water pollution, land-use impacts, the production of solid waste, as well as detrimental effects for wildlife and biodiversity. This is especially true in cases where states build fossil fuel plants in neighboring countries to supply their own domestic electricity needs.

As shown above, there are various issues relating to the potential impacts of the APG that have been contentious. However, this thesis does not seek to question

the conclusions reached by ASEAN and ASEAN governments in terms of the APG's net social and environmental benefits; hence, a deeper discussion on the social and environmental costs of the APG project lies outside the scope of this M.A. thesis. However, it is important to keep in mind that there will undoubtedly be losers from the APG development; it is up to ASEAN governments to address this through separate policies and regulation, especially if the benefits of the APG are to be distributed in a fair and equitable manner. In addition, this discussion also points to the importance of environmental impact assessments (EIA) and environmental, social, and governance (ESG) requirements as key conditions for the development of each electricity interconnection and power generation project within the APG framework. These will be crucial to reduce the project's negative impacts, thus contributing to the APG's goal of achieving regional sustainability.

2.4 Current State of the APG Project

To date, the APG project has achieved measured progress in terms of physical infrastructure development. As of 2016, nine bilateral interconnections have been constructed with a total capacity of 5,200 MW (Hermawanto, 2016). Six more cross-border projects with a capacity of 3,300 MW are currently under construction, and are expected to be commercially operational by 2018 or 2021. In addition, 16 additional interconnections have been planned for after 2020, which will bring another 23,200 MW of cross-border transmission capacity to the region's power system. With the development of physical infrastructure, the APG has been able to expand bilateral electricity trade in Southeast Asia; for example, Lao PDR has effectively quadrupled its electricity exports from 2.8 TWh in 2000 to 12.5 TWh in 2013, with Thailand as the main beneficiary (IEA, 2015b).

Despite these successes, the APG project has also faced various challenges to its implementation. In terms of physical infrastructure development, most interconnection projects currently under construction are up to two years behind the schedule set by the AIMS II report (Andrews-Speed, 2016). There is also a significant financing gap that the APG project has yet to bridge – in fact, some of the APG's

projects may never be financed as they are not deemed commercially viable. Furthermore, various governance hurdles on both a national and regional level are impeding the expansion of physical APG connections and the deepening of power market integration between national grids in the region. Overcoming these will be especially crucial if the APG project is to move to its second phase of implementation.

Multilateral Power Trading in Southeast Asian Sub-regions – GMS Power Connectivity and LTMS Power Integration

As mentioned, the APG project has not yet transitioned to the Phase II of its implementation, which involves a shift from bilateral to multilateral trading. Currently, the Global Mekong Sub-region (GMS) project and Laos-Thailand-Malaysia-Singapore Power Integration Project (LTMS-PIP) are two overlapping sub-regional projects in Southeast Asia that aim to achieve multilateral power trading.

The GMS comprises Cambodia, Lao People's Democratic Republic (Lao PDR), Myanmar, Thailand, Viet Nam, and Guangxi Zhuang Autonomous Region and Yunnan Province in the People's Republic of China. Geographically, the GMS makes up the Northern sub-region of the APG, and is considered the most developed out of all the sub-regional grids (Pacudan, 2016). **Table 1** lists the proposed AIMS II connections that fall within the GMS as of 2013 (ADB, 2013):

Table 1: Selected GMS Interconnection projects proposed under AIMS II

Systems	Capacity (MW)	Year
Cambodia – Thailand	300	2015
Lao PDR – Thailand	600	2015
Myanmar – Thailand	3,829	2016 – 2025

Cambodia – Thailand	100	2017
Cambodia – Vietnam	222	2017
Lao PDR – Thailand	3,521	2017 – 2023

Source: ADB, 2013

GMS electricity market cooperation should be seen within the broader framework GMS Economic Cooperation program, which began in 1992 with the purpose of achieving greater connectivity, economic competitiveness, and creating a greater sense of community in the region. As part of this overarching framework, power sector integration is meant to ensure the development of adequate power supply to meet the needs of the growing GMS economies, while also deepening regional cooperation. The Asian Development Bank (ADB) and the World Bank (WB) are key partners for the project, sponsoring and co-financing many of the project's planned interconnections and power generation projects. In addition, the ADB also acts as the secretariat for the project, coordinating its activities, while also providing technical and logistical support to GMS institutions (ESMAP, 2010b).

The implementation of GMS power connectivity is envisioned in four distinct phases, as listed in (ADB, 2012):

Stage 1: Development of bilateral connections through power purchase agreements (PPAs). In this stage, there may also be some opportunity exchange of power using excess capacity of cross-border transmission infrastructure.

Stage 2: Grid-to-grid power trading between any pair of GMS countries, using the transmission facilities of a third regional country.

Stage 3: Development of transmission lines expressly for cross-border trading, with third-party access (TPA) to this infrastructure.

Stage 4: The creation of a competitive regional market, with multiple buyers and sellers executing trades within and across GMS participating countries.

In terms of the project's approach, the GMS power integration project – just like the APG – looks to initiate bilateral power trading as the first stage of development before multilateral arrangements. However, the GMS project is much more specific about the nature of regional integration envisioned – it aims to create an integrated competitive regional power market in the last stage. As mentioned in Chapter 1, the APG project does not do so. The approach to the creation of multilateral power trading in the GMS is clearly laid out in the two Memoranda of Understandings (2005; 2008) – in the second stage, excess interconnection capacity from the first stage can be used to facilitate transit trading with a third country. Under the third stage, more interconnections are to be constructed with open access rights, before complete regional market integration is achieved in the fourth (and last) stage. Furthermore, unlike the APG project – which focuses solely on developing cross-border transmission infrastructure – the GMS power integration initiative currently has almost 60 export generation projects that are under construction, planned, or proposed (ESMAP, 2010b).

At present, the GMS project remains in the first stage of development, with electricity trading conducted on a bilateral basis through long-term (PPAs) between national utilities. The institutional development under the GMS framework is not yet mature, and GMS governments have not been able to reach a formal agreement on the approach and timeline for achieving stage two of the project. There have also been strong concerns that the projects underlying GMS power sector development may have significant environmental and socioeconomic impacts, such as the loss of biodiversity as well as increased food insecurity (Finenko, Owen, & Tao, 2017).

The LTMS-PIP project was initiated in 2014 with a joint statement issued by the four participating governments. The project aims to facilitate the sale of up to 100 MW of power from Lao PDR to Singapore, through transmission lines in Thailand and Malaysia. It is intended as a pilot project for multilateral power trading within the APG framework, using existing infrastructure. However, Singapore has held off on its involvement in the arrangement, as its reserve margin is expected to remain above 70% in the next four years – much higher than the minimum requirements of 30% (EMA, 2016). In September 2016, the other three countries signed an MOU to formalize cooperation for the initiative's implementation. Much more analysis needs to be done on the viability of the project, especially since the eventual transit tariffs that are agreed-upon would directly determine the cost economics.

The implementation of the LTM(S)-PIP, as well as the second stage of the GMS electricity cooperation project, will be a crucial step forward for the regional power sector integration in Southeast Asia. It would require the creation of commercial arrangements for multilateral power trading, such as transit tariffs, procedures for handling congestion and disputes, as well as the achievement of a minimum level of grid synchronization (ADB, 2016; ESMAP, 2010b).

The next chapter of this thesis discusses the challenges faced by the first two phases of APG implementation in greater detail. It also summarizes various solutions that have been proposed in the academic literature, and analyzes them based on the feasibility of their implementation within a Southeast Asian context.

Chapter 3:
Challenges & Proposed Solutions to the ASEAN Power Grid

There are various challenges that will likely continue to hinder the construction of the APG's underlying physical infrastructure, and prevent existing infrastructure from deepening power trade in the region. This chapter explains these challenges in greater depth, and evaluates the various solutions proposed in the existing academic literature based on how feasible they can be implemented.

3.1 Challenges to APG implementation

Challenges affecting Phase I of APG Implementation

Phase I of the APG initiative focuses on the development of bilateral power transmission lines to facilitate cross-border power flows. The IEA (2015a) estimates that aggregate cost of constructing these interconnections (identified under the APG framework) would come up to 20 billion USD – too high to be met by the public budgets of ASEAN governments. This points to the importance of private sector participation as a crucial success factor for creating the underlying infrastructure of the APG.

However, private sector investments may be difficult to secure, especially because some of the APG's planned interconnection projects are not deemed to be commercially viable. In part, this is due to the complex geography of the region, which increases the capital costs of such investments (Andrews-Speed, 2016; IEA, 2014). In addition to the high capital expenditure requirements for each cross-border interconnection – which can come up to hundreds of millions of dollars – investors consider some of these projects to be high-risk investments due to political, social, and environmental considerations (Li et al., 2016). The risk to investors is exacerbated by the fact that profitability is dependent on future volumes of cross-border electricity trade, which is difficult to forecast. In addition, low or subsidized end-user tariffs (prevalent in many ASEAN countries) also directly impacts potential

revenues. These considerations have led to inadequate financing for APG interconnection projects, which helps explain why construction targets proposed under AIMS II have not been met (Shi & Malik, 2013).

Apart from the availability of adequate financing for these cross-border transmission projects, there is also the problem of allocating the cost of these projects among multiple parties. According to the IEA, "cost allocation methodologies that lack transparency, or do not fairly apportion the relevant costs can act as a significant barrier to development" (IEA, 2015a). This problem becomes even more complex because transmission infrastructure is inherently interconnected – the same IEA report raises the example that developing power interconnections between Sarawak and Kalimantan will be ineffective if Sarawak's internal transmission infrastructure lacks sufficient capacity or connections. In this case, further costs incurred for the development of Sarawak's power grid will have to be allocated.

Apart from the various financing challenges, there are significant governance hurdles that impede the progress of these interconnection projects. Examples of this include Malaysia's national regulations, which grant the government the sole authority to develop transmission lines; as well as Indonesia's onerous rules for justifying power interconnections with other countries (IEA, 2014). It is important to also recognize that wider governance issues are intricately linked to power sector financing – poor governance decreases the attractiveness of the business environment, especially for foreign investors; inefficient power markets lead to deadweight losses, which reduce the value and hence commercial viability of cross-border trading; unstandardized tax policies across Southeast Asian countries could render electricity trade prohibitively costly (Shi & Malik, 2013).

Challenges affecting Phase II of APG Implementation

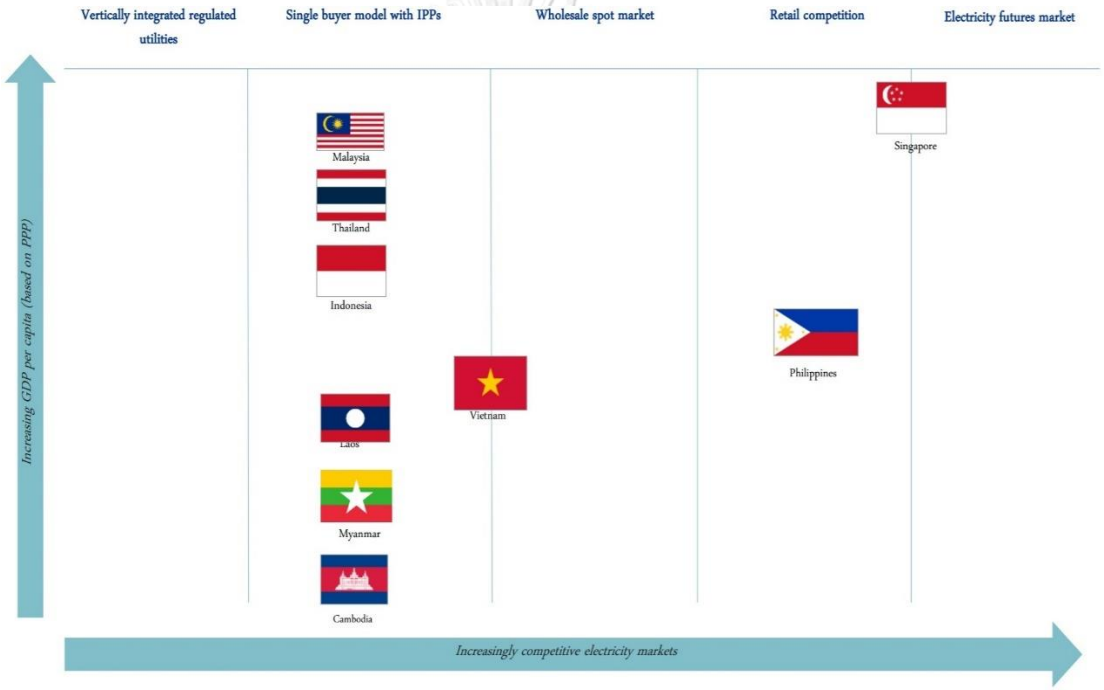
The APGCC has recently embarked on Phase II of the APG initiative, and plans to achieve multilateral power trading in one of ASEAN's sub-regions by 2018. However, even as the APG's physical infrastructure continues to expand, soft infrastructure development has lagged (Shi & Malik, 2013), preventing a deepening of cross-border power connectivity. This can be attributed to the absence of regional power sector coordination, as well as market distortions stemming from a lack of liberalization in some national electricity markets.

First, deeper regional coordination is required for ASEAN to successfully implement the second phase of APG implementation. Trading mechanisms would have to be developed to allow for electricity trades involving more than two countries, such as the appropriate wheeling charges that can be imposed by transit countries. In addition, the harmonization of grid codes is necessary for power imports to occur without grid instability and market inefficiencies; these include the rules that govern power system operation, such as outage planning and dispatch procedures (SARI/EI, 2016). Power market planning for generation and transmission capacity expansions will also have to be coordinated at a regional level, as it sends clear signals to policymakers that future capacity will be adequate to meet growing electricity consumption, and that the emergency reserve levels are also sufficient. All of this would likely require the creation of regional institutions such as a regional transmission system operator or market regulator.

Second, power sector organization and management tend to differ across ASEAN member states (Andrews-Speed, 2016). Southeast Asian countries are at various stages of domestic power market liberalization – while Singapore and the Philippines have been relatively successful at market liberalization and ownership unbundling, most other countries in the region continue to operate based on single-buyer models (Somani, 2015) with state-owned, vertically-integrated utility companies enjoying a virtual monopoly of the sector (see: **Fig. 2**). While single buyer

models and the existence of state-owned enterprises are not problems in and of themselves, they tend to be indicative of markets that are less transparent. These entrenched vested interests in the domestic power sector could lead to market distortions which reduce the opportunities for cross-border trading – examples of these include the utilization of import taxes and domestic producer subsidies to protect the dominant monopoly from competing for market share with electricity imports.

Fig. 2: Power Market Structures in Southeast Asia, 2015



Source: KPMG Singapore, 2015

Third, the lack of third party access to transmission infrastructure is one method through which the company that owns and operates the transmission grid can exercise its monopoly power. In this way, market competition is restricted based on dominance of one link in the power industry supply chain, which prevents electricity trade from emerging based on supply and demand imbalances. Without such TPA arrangements, even if all the proposed interconnections were completed, the APG would remain as a collection of bilateral interconnections, rather than evolve into an integrated regional power market (Shi & Malik, 2013). Of course, it is also important to recognize the real market considerations which explain the existence of these

contractual arrangements – due to the high capital costs, the construction of most cross-border transmission lines utilize project finance mechanisms. This usually necessitates in long-term power purchase agreements accounting for almost the entire capacity of the transmission line, which then allows private sector investors or lenders to see quick and stable returns on their investment. Hence, there is little spare capacity available for third parties to engage in electricity trading – at least, not until these contracts expire and the capital costs of such projects are fully recouped.

Fourth, the existence of domestic energy subsidies is also a barrier to cross-border power trading. In Malaysia, the government continues to mandate that *Petronas* provide electricity generators with natural gas at subsidized prices (IISD, 2013). Not only does this create a drag on *Petronas'* finances, it also prevents imported electricity from becoming cost-competitive with domestic power generation. Similar situations are found in other gas-exporting countries such as Brunei and Indonesia, where electricity producers are provided gas at sub-market prices to "support electricity tariffs which are below costs of production" (Doshi, 2013). The IEA estimates that the total economic value of Southeast Asia's fossil fuel subsidies in 2014 amounted to 36 billion USD. In Indonesia alone, domestic electricity market subsidies were estimated at 8 billion USD that same year (IEA, 2015b).

Proposed Solutions for the ASEAN Power Grid (APG)

The existing academic literature proposes a range of solutions to address the APG's various challenges. To bridge the financing gap, the literature suggests tackling this issue on a regional level. Both the IEA (2015a) and Shi, et al. (2013) state that the APG project provides a regional public good; hence, Shi, et al. proposes the creation of a collective ASEAN fund to share the costs of the APG among ASEAN member states. However, public finance is grossly inadequate to meet the requirements of the APG plans (IEA, 2015a) – it is crucial to mobilize other sources of financing, through partnerships with the private sector as well as regional or international organizations. For example, the Asian Development Bank (ADB) has approved hundreds of millions of dollars' worth of financing for GMS power projects, in the form of loans and political risk guarantees. This does not include the additional $10.4 million that the ADB has sponsored in the form of technical assistance for GMS power connectivity projects (ADB, 2016).

Here, Southeast Asian policymakers also have an important role to play. Targeted financing and public guarantees can make more APG interconnections economically feasible for private sector investors, and more attractive for multilateral lending agencies (IEA, 2015a). In a broader sense, ASEAN governments should also create a legal and regulatory environment that is attractive for foreign direct investment, such as having "rule-based and transparent market institutions." (Li et al., 2016). Li, et al. goes on to state that private sector investors and international organizations are not just important sources of financing, but can also provide relevant skills and knowledge, as well as technical and logistical support for APG implementation. For example, as previously mentioned in **Chapter 2**, the ADB has acted as the de-facto secretariat of the GMS power connectivity initiative since its inception (ADB, 2016), while both the ADB and the IEA have conducted technical studies for power connectivity in Southeast Asia.

With regards to the issue of cost allocation for the development of transmission infrastructure, the conventional wisdom has been that the "beneficiary pays" principle, whereby costs are apportioned commensurate to the benefits that each party gains from the project, is the most logical (IEA, 2015a). However, this process is much more complicated than it seems, especially when non-economic costs and benefits are significant yet difficult to measure; such as the environmental damage that may arise from a transmission project.

To address the governance challenges of the APG, the existing literature proposes both regional- and national-level solutions. On a regional level, Andrews-Speed (2016) summarizes the findings of a series of studies by HAPUA, the ACE, and the ADB in 2013, which all highlight "the need to harmonize legal and regulatory frameworks relating to power interconnection and trade, as well as technical standards and codes relating to planning, design, system operation and maintenance." This view has also been echoed in other studies (Doshi, 2013; Li,2013). In 2016, the head of the ASEAN Power Grid Consultative Committee (APGCC) also pointed out the need for harmonization of national energy laws (Hermawanto, 2016). The IEA (2015a) has proposed creating institutional structures to achieve this, such as an institution to coordinate transmission system operators in ASEAN, as well as for regional generation and transmission system planning. HAPUA has commissioned feasibility studies for this purpose (Andrews-Speed, 2016).

On a national level, most of the existing academic literature repeatedly points to 'behind-the-border' barriers – which include the lack of privatization and liberalization of the domestic power sector, as well as the presence of energy subsidies – as the primary reason for the APG's relatively slow development (Shi & Malik, 2013). From this perspective, it makes sense that 'behind-the-border' solutions should be prioritized as a precondition for the development of a regional electricity market – the IEA (2015a) suggests that power sector development requires the depoliticization of electricity governance; thus, it proposes the creation of independent (and strong) national regulatory authorities to prevent executive

influence over power market regulation. Doshi (2013) and Shi, et al. (2013) both emphasize the importance of market-based pricing, and recommend that gas and power market subsidies in ASEAN member countries be removed. Other academic publications, such as Li, et al. (2016), also calls for the deregulation of domestic markets, as well as the unbundling of vertically-integrated utilities.

3.2 Analysis: A Critique of the Feasibility of Proposed Solutions

Regional-level solutions

A range of political and economic factors within ASEAN may severely impair the feasibility of implementation of most of the proposed regional-level solutions. Beyond the creation of ASEAN institutions, more tangible regulatory and power market harmonization on a regional level has been elusive, mainly due to: (1) national conceptions of energy security; (2) difficulties in allocating the APG's costs and benefits; and (3) the lack of mutual trust.

Hermawanto (2016) explains the situation in ASEAN today, where countries in Southeast Asia desire self-sufficiency before allowing for electricity interconnections to be developed. For power market integration to work, what is required instead is a fundamental shift from a national to a regional conception of energy security – if ASEAN members do not pursue energy security on a collective level, the APG's benefits (of reducing the capacity and reserve requirements of each country) will be negated. Further, this also acts as a barrier to APG development, as the "materialisation of trade opportunities" is reduced when countries opt to limit their dependence on imported electricity (Shi, et al., 2013: 51).

The lack of trust appears to be another issue preventing the institutionalization of regional coordination. The creation of regional TSOs as well as institutions for regional power market planning may require greater political will; this problem becomes clear when considering the Greater Mekong Sub-region (GMS) project, where participating countries have struggled since 2010 to establish a Regional Power Coordination Centre for the synchronization of domestic market

operations, due to disagreements on who should host this body (Andrews-Speed, 2016). Similar to ASEAN, the GMS project also operates based on consensus, which could explain the relatively slow pace. However, its decision-making mechanisms could have been complicated by the inclusion of China as a major player in the project.

The challenges to institutionalizing electricity cooperation in ASEAN are evident from the experience of other similar initiatives. While the ASEAN Petroleum Security Agreement (APSA) was signed by ASEAN foreign ministers in 2009, establishing emergency response measures to achieve regional petroleum security, it is not legally binding (ASEAN, 2009). This means that the "commitments" made by ASEAN member states' to grant petroleum assistance to countries in distress is purely voluntary. Further, ASEAN's attempts to create a common regional oil stockpile has also faced complications, mainly due to disagreements over the location and purpose of such supplies, as well as which country would be responsible for managing them (Nicolas, 2009).

"Behind-the-border" solutions

National-level solutions – which include market liberalization through deregulation, domestic market ownership unbundling, and the removal of energy subsidies – tend to be politically inexpedient. Wu explains that the political will for the APG project could have been "compromised due to vested interests (and) nationalism"(Wu, 2016). Similarly, Finenko (2016) states that a significant challenge to the APG has been government concerns over power market liberalization (Finenko, 2016). In fact, Sulistiyanto, et al. (2004), in the context of analyzing the process of power sector restructuring in Indonesia, the Philippines, and Thailand, goes so far as to conclude that "political factors, institutions, actors and their interests are as important, if not more so, as economic and technical considerations" (Sulistiyanto & Xun, 2004). In some countries in the region, there are strong incentives to protect politically-connected market players within the national electricity market, which effectively prevents domestic power sector liberalization.

First, removing the high levels of consumer-side electricity subsidies in the region has proven to be politically unpopular. Jones (2016) argues that consumer-side energy subsidies have been used to maintain broad-based support for oligarchic rule in Southeast Asia, and is also part of the dominant paradigm of state-led economic development in this region. He points to Suharto's fall in 1998 after enforced cuts to energy subsidies as a cautionary tale of the social unrest and political instability that could ensue (Jones, 2016).

In reality, there has been strong debate about both the potential socio-political impacts of removing energy subsidies. Wu, et al. (2011) suggests that subsidy reductions related to the APG would seriously impact workers' incomes. However, a report by KPMG has pointed out that in Southeast Asia, such subsidies are unevenly distributed – in fact, over 90% of energy subsidies help the middle- and high-income groups instead. Hence, while there *is* a need for a social safety net to protect low-

income consumers, it is unclear whether the current approach to fuel subsidies is necessarily the best way to achieve this (KPMG, 2013).

Regardless, it is the perceived rather than actual impact of electricity subsidies that is politically significant. The threat of popular unrest and the fear of losing elections continue to deter governments from aggressively removing consumer subsidies. Jones (2015) concludes that ASEAN governments have instead opted for the path of least resistance for APG implementation – bilateral interconnections are pursued only in cases where it is economically feasible to construct them without the imposition of significant adjustment costs.

Southeast Asian countries have in recent years demonstrated considerable political will to phase out energy subsidies (IEA, 2015b). The current low oil price environment, together with national budgetary constraints and the poor performance of state-owned enterprises in the energy sector has provided a strong impetus for this. However, these opportunities may be limited as the issue of fuel subsidies continues to be politically sensitive and governments continue to adopt an extremely cautionary approach.

Second, market liberalization – through privatization, vertical unbundling of the incumbent utility, and the creation of wholesale and retail electricity markets – has been repeatedly proposed as a solution for the APG (Doshi, 2013; IEA, 2015a; Li et al., 2016; Shi & Malik, 2013). However, this is difficult to implement in some Southeast Asian countries due to the entrenchment of interests of "powerful electricity elites" (Sharma, 2005). Juego (2015) explains how market liberalization and privatization go directly "against the domestic vested interests of these politically connected businesses and corporations." Without greater liberalization, it would be difficult to realize the ASEAN Economic Community's vision of 'open regionalism' (Juego, 2015). According to Juego, national oligarchies in Southeast Asia tend to have significant political influence over policy decisions, and have been successful in

resisting liberalization measures that are "deemed to challenge their monopolies or put their businesses at high risk of losing when faced with competition."

In some cases where ASEAN governments have taken steps towards market liberalization, vested political interests explain why these liberalization attempts have mostly been in form rather than substance. Due to the prevalence of cronyism in Malaysia, the sale of 30% of Tenaga's stake on the Malaysian stock exchange simply led to wealth transfer from the public to government cronies who owned shares in the state-owned electricity utility company, rather than the creation of market competition and efficiency (Nikomborirak & Manachotphong, 2007). Without privatization and the primacy of market forces, Nikomborirak, et al. argues that the creation of wholesale electricity markets is meaningless at best, and risky at worst, since the market would be dominated by existing incumbents. Hence, she concludes that competition in the wholesale market should not yet be enforced in Thailand, Malaysia, Indonesia and the Philippines, due to the existence of dominant sellers. Going one step further, she states that without competition in wholesale or retail markets, vertical unbundling of utilities is also meaningless. Her arguments go to the heart of the debate about the sequencing of market liberalization steps, which lies beyond the scope of this thesis.

In addition to the presence of vested political interests, nationalistic tendencies and the strength of domestic labor unions in the power sector also impede power sector liberalization. Under the Thaksin administration in Thailand, the overarching government policy was to create national champions in the power sector through privatization, but without opening the market up to competition. This was due to fears that foreigners would hold stakes in power generation companies, leading to a rise in electricity prices (Nikomborirak & Manachotphong, 2007). However, even these limited attempts at privatization were fiercely opposed by domestic power sector unions – the privatization of EGAT had originally been planned for early-2000, but did not materialize due to strong opposition from

EGAT's employee union. In addition, EGAT's employees have also prevented the state-owned utility from becoming vertically unbundled.

Third, the strong political links between the government and the electricity sector also explain why the creation of an independent regulator has been almost impossible in some Southeast Asian countries. The fact that electricity markets are highly politicized in these countries means that it has been difficult to create independent institutions able to resist the subjugation of market efficiency considerations under larger political and geo-strategic agendas (Sharma, 2005). Ironically, the absence of independent regulation has led to the further entrenchment of these symbiotic relationships. Even if it were possible to establish independent power sector regulation, this would constitute a long and difficult process – to function effectively, the regulator must have a comprehensive understanding of the domestic power sector, but such experience takes a long time to acquire (Thomas, 2006).

3.3 Conclusion

A deeper, more nuanced understanding of the socio-political context in Southeast Asia enables us to critically evaluate the feasibility of common solutions that have been proposed in the face of the APG's challenges. However, this leaves us with an unsettling question – what next?

One potential implication is that, based on the history of electricity market reform in Southeast Asia, power crises are required in order to harness the political will and public support necessary to facilitate the deepening of market liberalization and regional coordination. The wave of power sector liberalization in Southeast Asia in the 1980s and early 1990s came in the wake of electricity crises – power shortages and blackouts in the Philippines, Peninsular Malaysia and Indonesia, coupled with a lack of government budgetary capacity to finance the expansion of domestic power generation capacity, led to domestic market reforms aimed at attracting private capital (Sharma, 2005). Of course, this "solution" seems unsatisfactory – given the

potential political and economic costs, governments would ideally pre-empt such crises rather than react to them. In fact, the APG is one of the solutions intended to increase regional electricity security.

What becomes clear is that the traditional prescriptions for the APG's first two phases may not be feasible for implementation, based on a deeper understanding of the regional context. Wu (2016) is one of the few academic papers that does *not* suggest market liberalization as a pre-requisite for the APG, acknowledging the problem of political expediency. Instead, the solutions proposed by Wu's study are explicitly in line with the "ASEAN way" of making progress through consensus-building. Wu states that ASEAN can help build national capacity and encourage partial domestic reform with the goal of intra-regional trading in mind, "without interfering in a member state's internal affairs" (p.119). In addition, Andrews-Speed (2016) also challenges the "accepted wisdom" of the domestic market liberalization as a pre-requisite for the creation of a regional market, based on the experiences of the Nordic Power Pool, and its subsequent adaptation to Southern Africa.

Given this context, this thesis proposes exploring the creation of a regional power exchange as a way to deepen regional power sector integration, while limiting the need for intervention in domestic electricity markets. The rationale for the ASEAN electricity exchange (AEE), and the way that it addresses the socio-political constraints in Southeast Asia will be further discussed in the next chapter.

Chapter 4:
The ASEAN Electricity Exchange (AEE)

As evident from the previous chapter, any approach to the creation of a regional power grid must consider the social and political realities of Southeast Asia. Against this backdrop, even as the implementation of Phase I and II of the ASEAN Power Grid are currently underway, HAPUA has also commissioned a feasibility study for the creation of a regional electricity exchange to deepen power market integration.

While the vision of the ASEAN Electricity Exchange (AEE) has not yet been defined by the APGCC, it is important to first understand what a power exchange is. Without delving too deeply into the details the ownership structures and operating mechanisms of a functioning power exchange, a power exchange can be conceptualized, in its simplest form, as *a marketplace where power suppliers compete to sell electricity to Load Serving Entities (LSEs),* which are also known as retail companies.[4]

This chapter explains the background and rationale for the AEE initiative, and discusses how the creation of a regional power exchange could serve as a compromise solution, which may successfully address or circumvent many feasibility issues mentioned in Chapter 3.

4.1 Background on the ASEAN Electricity Exchange

The idea of the AEE first transpired from the ASEAN Energy Market Integration (AEMI) initiative's workshop in November 2015 on *Energy Security and Connectivity*, jointly organized with the Energy Studies Institute in Singapore.[5] The

[4] While this implies the existence of some form of competitive trading mechanisms, it does *not* mean that the market is fully competitive – levels of market competition lie on a spectrum, depending on a variety of factors such as the concentration of market power. In addition, the special physical characteristics and requirements of electricity markets (such as its public-good attributes) necessitate in non-market mechanisms (P. Joskow & Tirole, 2007).

[5] It is also worth mentioning that the idea of a power exchange is not new to Southeast Asia. In fact, a "wholly competitive regional market" for electricity trading has been proposed as the fourth and final stage of power

forum aimed to develop governance approaches to the ASEAN power grid project – with an emphasis on the LTMS-PIP project implementation – through learning from the Nordic experience of regional power sector integration (AEMI, 2015b). It seems that the Nordic Pool was identified due to its relative maturity and success compared to other regional power connectivity initiatives. Forum participants then realized through the forum discussions that the creation of a commodity exchange for electricity trading, as in the Nordic experience, facilitated price discovery. In addition, the forum concluded that this approach did not require vertical unbundling or privatization of utilities, or even the complete removal of energy subsidies (AEMI, 2015a).[6] This recognition was crucial for the APG, given the feasibility issues attached to many of these steps at domestic power sector reform (see: **Chapter 3**).

Building on these insights, a HAPUA-AEMI conference was convened in May 2016 to discuss the features of the Nordic pool in greater detail, with a focus on how it was adapted for implementation in Southern Africa. The objective of this process was to determine if the creation of an ASEAN Electricity Exchange based on the Nordic model could help move APG connectivity to a multilateral level (AEMI, 2016). At the end of the forum, participants unanimously recommended that a feasibility study be conducted to assess the effectiveness of the AEE as an approach for APG project. This was approved a few months later in September 2016, during the 34th ASEAN Ministers of Energy Meeting (AMEM), where the ministers also called for an APG Special Task Force to implement the study (AEMI, 2017a).

As of the writing of this thesis, the latest update on the AEE initiative was in April 2017, when another AEMI workshop (jointly organized by HAPUA and UN ESCAP) was convened to analyze how power exchanges were created in different regions around the world, as a starting point for the feasibility study. In addition, the workshop also confirmed that the implementation of a regional electricity exchange

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connectivity in the Global Mekong Sub-region, as part of the Regional Power Trade Operating Agreement in 2004 (ADB, 2016). While the GMS has now been subsumed as one sub-region of the APG initiative, the APG as a whole has only recognized the goal of creating a competitive regional power exchange with the AEE.

[6] However, the AEMI forum concluded that energy subsidies would have to be decoupled from power prices to avoid market distortions.

in ASEAN could co-exist with bilateral and multilateral contracts for power trade. Participants also agreed on certain core principles for the "ASEAN model" of a regional power exchange (AEMI, 2017b):

(1) Adopt a stepwise and voluntary approach whereby ASEAN member states join on a voluntary basis when they are ready.

(2) Trade gaps and excesses only; with sellers voluntarily trading excess supply in national generation capacity, and buyers covering demand gaps.

(3) Establish incentives for expanding regional power infrastructure through mechanisms for shared costs-benefits.

(4) Develop a regional pricing model for cross border trade including a wheeling pricing model.

(5) Incorporate sustainability for power trading through enhancing the deployment of renewable energy.

Apart from these, there have yet to be specific recommendations for how the AEE will be structured.

4.2 ASEAN Electricity Exchange as a "Compromise Solution" for APG Implementation

Essentially, the value of the AEE as an approach to APG implementation is that it creates a parallel market that functions on a regional level. This can be expanded and developed concurrently with the domestic power market, without requiring a significant restructuring of the domestic market. In this way, the power exchange envisioned by HAPUA and AEMI helps to address some of the political feasibility issues of the APG's first two phases. Through trading only surplus electricity capacity on a voluntary basis to meet demand gaps across borders, it does not require significant interference within national markets – such as complete market liberalization or changing the ownership structures of utilities (AEMI, 2017b). Some steps at market reform must undoubtedly still be undertaken for the power

exchange to function even in this limited form. These will be further discussed in the next chapter, based on the experiences of other regions in creating regional power exchanges.

The creation of a platform for the trading of electricity surplus to plug demand gaps across borders can bring with it significant process benefits and outcome benefits. The **process benefits** refer to the systems and structures that ASEAN governments will need to put in place to facilitate the AEE's functionality. These tend to be focused on the technical aspects of trade, such as:

- Provision of third party access (TPA) to transmission lines, both cross-border and domestic;
- Creation of a harmonized approach to regional power pricing, including agreement of wheeling/transit pricing;
- Coordination of market operations across borders to ensure grid stability; and
- Creation of institutions and procedures for the operation of the power exchange, including mechanisms for physical and/or financial trades (eg. day ahead market).

This list is non-exhaustive; nevertheless, these examples of cross-border technical and pricing coordination will be crucial for the deepening of cross-border power market integration within Southeast Asia. Of course, the same process benefits can also be gained through simply implementing these prescriptions without the creation of a regional electricity exchange. In fact, some of them will have to be applied for ASEAN to successfully achieve multilateral trading under Phase II. However, the AEE would provide a specific target for member states to work towards, while the various outcome benefits could also make the process more politically expedient – by providing a rationale or additional incentives for national policymakers to push through these policies.

There are also various **outcome benefits** that can be derived from a functional power exchange to trade surplus electricity in Southeast Asia. The most overwhelming of these benefits is that the creation of a platform for buyers and sellers to trade surplus power results in price discovery, through uniform pricing of marginal electricity supply. These prices are especially important in a region where some level of market distortion exists in most domestic markets, as they provide (relatively) transparent market signals that can lead to the efficient utilization of surplus electricity generation resources. In addition, as the power exchange gradually gains traction, there would be greater trust in its market signals, as well as increased confidence on the part of policymakers to meet domestic electricity consumption requirements by relying on cross-border trades.

Here, it is important to point out the limits of price discovery that occurs with the AEE in its circumscribed form, where only surplus electricity is traded. This is directly related to the distinction between short-run and long-run marginal costs. When a power generation company sells only surplus electricity on the power exchange (presumably, the rest of its generation capacity is contracted out on a long-term PPA), there is a very low price-floor set for these electricity trades. This is because the uncontracted capacity would not have been utilized anyway, and any price above the short run marginal cost leads to a profit being generated for the firm. Hence, while importers of electricity benefit from competitive rates, this could lead to market distortions since it does not necessarily reflect the true cost of electricity production. In addition, pricing on the short-run marginal cost tends not to provide the right market signals that would incentivize investment in power generation assets.

However, as the AEE begins to function, policymakers and companies alike would start to build greater trust in other market participants, as well as in the power exchange itself. In this way, there is the potential for this to create additional incentives for the expansion of the share of exports or imports out of total domestic electricity production and consumption, respectively. This could result in greater

coverage for the regional electricity exchange, eventually expanding into a full regional power exchange model.

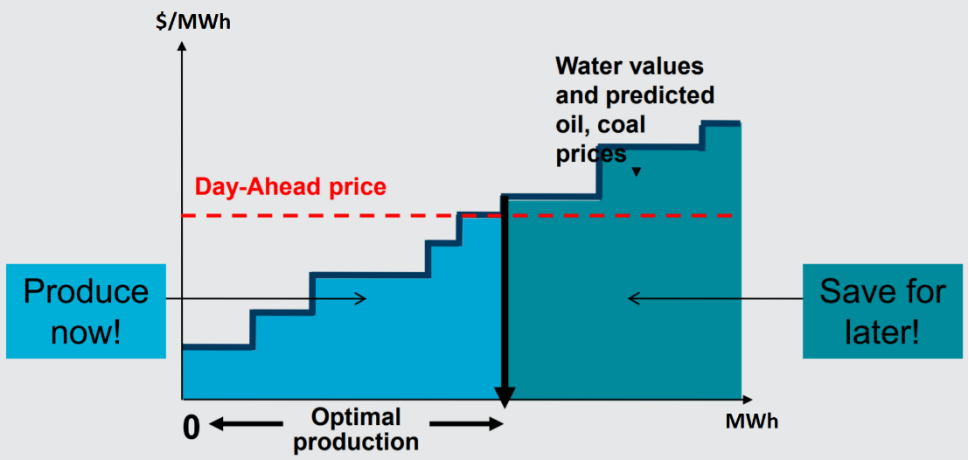
4.3 Full Regional Power Exchange Model

As mentioned, the AEE as a compromise solution would likely be more politically expedient in terms of its implementation, as it does not require full market liberalization. However, this thesis proposes that by first creating a platform that allows for some level of electricity trading at free market prices, it could serve as a pathfinder for eventual evolution into a full regional power exchange – one that may eventually encompass a substantial proportion of the region's power supply and consumption. This would, however, require deeper efforts at domestic market liberalization, without which distortions in the regional market would result.

The benefits of a full regional electricity exchange that trades more than just surplus capacity could be substantial. The effects of such a power exchange would be similar to those stemming from the creation of competitive domestic wholesale markets, where market pricing is at the economically efficient level based on supply and demand balances that reflect true costs. This is supported by a study by the Institute of Electrical and Electronics Engineers (IEEE), which concluded that within functioning spot markets for electricity trading, efficient allocation is always achieved in any Nash equilibrium (Song, Liu, & Lawarrée, 2002). Economically-efficient pricing can thus provide better incentives for a reduction of both capital and operational costs for generators, as well as greater service quality from network operators, while also transferring the risks from technology choice, construction costs and mistakes from consumers to suppliers (P. L. Joskow, 2008).

With market-based pricing of regional power resources, short-term dispatch decisions (i.e. which electricity resources and power generation assets to be utilized) would be made based on a lowest-cost basis, as shown in **Fig. 3** (Bredesen & Söderström, 2016):

Fig. 3: Dispatch decisions for different power sources based on current & future pricing

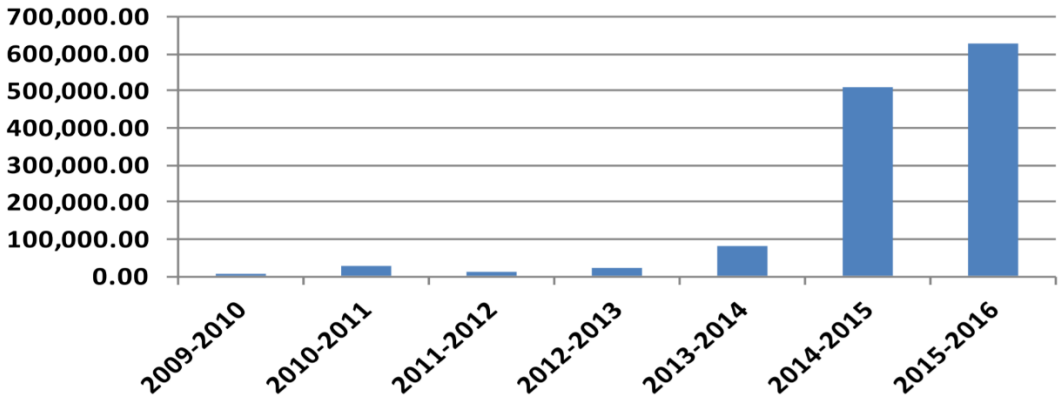


Source: Nord Pool Consulting, 2016

In the later stages of the AEE, the potential for utilities to optimize costs through the power exchange could incentivize trading over "striving for self-provision"(AEMI, 2016). This would have a significant positive impact on long-term power planning, as lower-cost generation assets would be developed to replace generation assets elsewhere in the region that are less efficient.

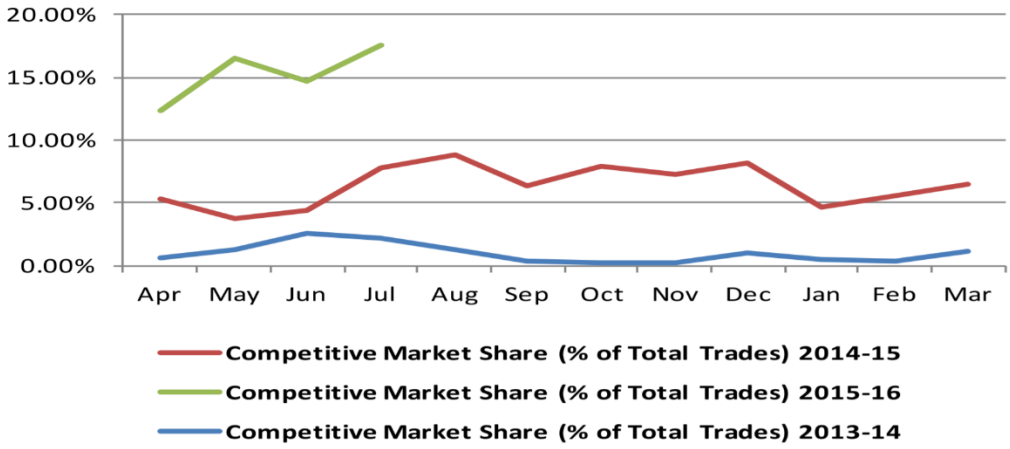
The potential for expanding electricity trading within the AEE beyond surplus generation is uncertain, with many domestic political and economic hurdles that must be overcome. However, previous experiences in other regions provide some cause for hope. In particular, the Southern Africa Power Pool (SAPP) also began with relatively limited levels of trading on the exchange, but this has increased rapidly as participating countries gained more trust in the market (see: **Fig. 4** & **Fig. 5**). Since the creation of the electricity exchange in 2009, the volumes of competitive electricity trades in the region have grown at a high rate, reaching more than 600,000 MWh by 2016. Meanwhile the market share of these competitive trades has also risen from less than 3% to around 15%, in the short span of 2 years, from 2013 to 2015 (Bredesen & Söderström, 2016).

Fig. 4: SAPP Traded Volumes on the Competitive Market (MWh), 2009 – 2016



Source: Nord Pool Consulting, 2016

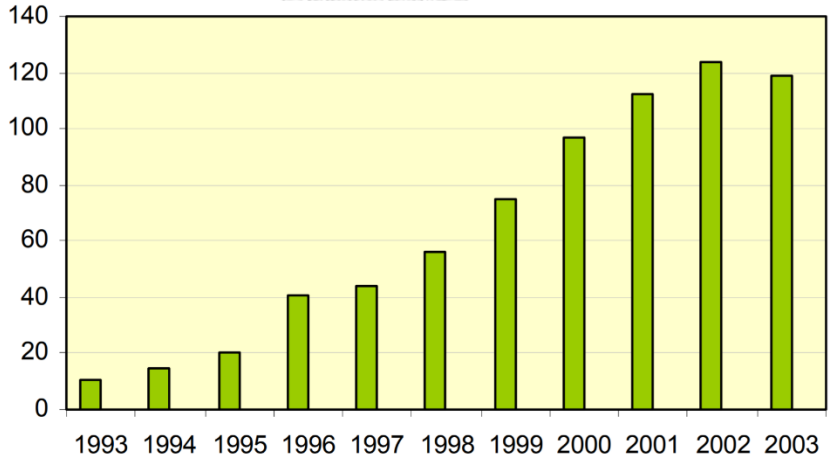
Fig. 5: SAPP Market Share of Competitive Trades (% of total trades), 2013 – 2015



Source: Nord Pool Consulting, 2016

The same trend is also reflected in the growth of the Nordic Power pool, where the traded volumes increased twelve-fold within the span of a decade (see: **Fig. 6**). By 2003, the spot market's traded volume was 119 TWh, equivalent to 31% of overall Nordic consumption (NordPool, 2004a).

Fig. 6: Traded Volumes on the Nordic Pool (TWh), 1993 – 2003



Source: NordPool, 2004

The rapid growth in traded volumes in both power exchanges shows that regional power exchanges can quickly gain traction among market participants and governments alike as they start to see the benefits of power trading, and begin to build trust in the price signals.

4.4 Potential Disadvantages of Trading Electricity on a Regional Exchange

Efficient markets do not necessarily benefit everyone in a conventional sense; to assume so would be a fallacy. The creation of a competitive regional power exchange which allocates electricity resources on an economically efficient basis would disadvantage domestic power generation industries in countries with high costs of power production as well as lower-income consumers in the region, while at the same time possibly leading to energy security vulnerabilities.

In terms of the effect on **domestic industries**, Oseni and Pollitt (2014) argue that with greater integration, some countries become more reliant on imports of electricity – especially if import prices are lower than the costs of domestic generation (Oseni & Pollitt, 2014). This would likely lead to the closure of less efficient domestic power generation facilities, thus, increasing electricity dependence. The tendency to protect domestic power suppliers is a very real concern even in competitive electricity markets that are relatively mature – the US Department of Energy (2017) identified one of the largest barriers to US-Canada power trading as the concern that cost-effective Canadian hydropower would give Canadian suppliers greater market power over US generators (DOE, 2017).

The creation of an ASEAN competitive power market also implies that electricity prices will equalize at a market-clearing regional price. For countries such as Singapore with extremely high electricity tariffs, domestic consumers can expect to enjoy cheaper electricity. Conversely, other countries in the region that currently enjoy comparatively low electricity prices would expect to face higher tariffs. These higher prices could potentially disadvantage the poor in Southeast Asia in terms of access to energy; in addition, efficient allocation within such a market also implies that there will be a tendency to allocate scarce domestic electricity resources abroad in the pursuit of higher revenues.

For example, in developing countries such as Lao PDR, the average monthly income is significantly lower relative to the rest of the region (ILO, 2014b), which

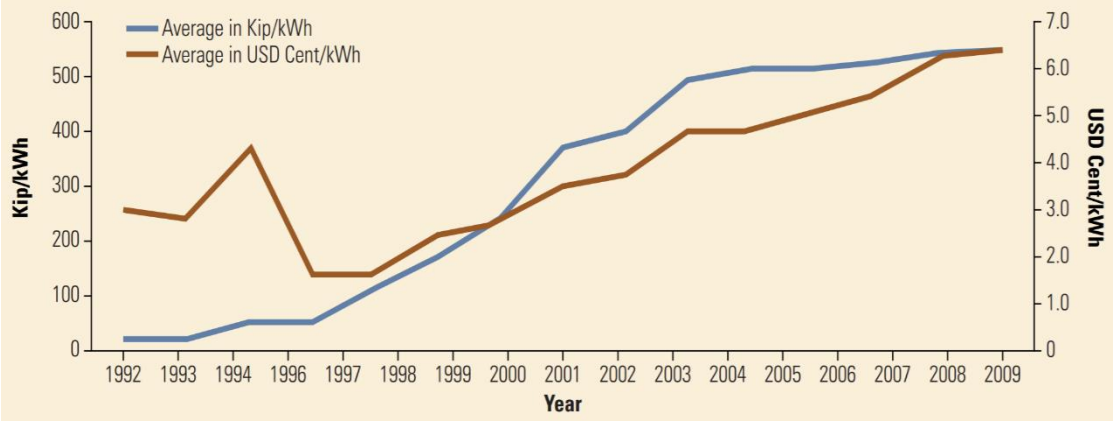
partly explains the country's low levels of electrification. As shown in **Fig. 7**, electricity tariffs in Lao PDR are also currently much lower as compared to most other ASEAN countries (ILO, 2014a; Somani, 2015). In the short run, this favors the development of export-oriented power generation projects. As a result, average electricity prices have been gradually increasing since 1996 (See: **Fig. 8**). These prices will be expected to rise even more in the long run with the creation of a full regional competitive power exchange, equalizing at the market-clearing regional price (WB, 2012). These higher prices faced by Laos would likely render electricity even more unaffordable for the millions of lower-income consumers in the country.

Fig. 7: Average Income & Electricity Tariffs in Southeast Asia

*Lao PDR average monthly wage data accurate as of 2012, taken from International Labor Organization report

Source: KPMG Singapore, 2015; ILO, 2014

Fig. 8: Average Electricity Tariffs in Lao PDR, 1992 – 2009



Source: World Bank, 2012

Hence, while the net benefits of power trading are significant, these issues point to the importance of the government in ensuring that these benefits are distributed in an equitable manner, through effective policymaking. This would include financial assistance and skills re-training for workers in declining domestic sectors, as well as safety nets to ensure that the region's poor can afford electricity. However, with power trading, governments would theoretically be in a better position to do so. For example, in the case of Lao PDR, development of the national grid has been slow due to a lack of financial resources; this effectively limits the electricity services which rural populations have access to. With the income generated from power exports, the Laotian government would be able to afford the development domestic infrastructure, as well as implement other development-oriented policies that would improve the lives of the underprivileged communities. In the long run, effective governance backed by government revenues from electricity exports would serve to raise average household incomes, as well as improve both standards and quality of living.

Here, it should also be pointed out that increased reliance on foreign countries to meet domestic electricity consumption needs gives rise to perceived energy security vulnerabilities. This has already been discussed at length in **Chapter 2**. As a final note on this issue, Oseni and Pollitt (2014) also assess this risk to be

manageable – they point out that the exporting country is also equally dependent on electricity trade for export revenues. Hence, there is a relatively low probability of the exporting country cutting off cross-border power supply. However, this says nothing of the risk to grid stability arising from a wide-area synchronous network (which led to cascading blackouts in the East Coast of the US in 2003).

Since the AEE is still in its conception/feasibility phase, few conclusions have been reached about how it would be implemented, as well as the form that it will take. Having discussed the benefits and rationale for the AEE, the next chapter will analyze the experience of other regions in creating their own regional power exchanges, to derive lessons relevant for ASEAN's own initiative.

Chapter 5:
Scope of Analysis – Academic Literature and Regional Power Exchanges

The previous chapter has explained the benefits of the ASEAN Electricity Exchange's (AEE) creation as a compromise solution to APG implementation. Chapters 5 and 6 turn to other competitive regional electricity markets that are currently functional, in order to recommend certain features, structures, and approaches for the AEE.

To this end, this chapter first explains the proposed structure and fundamental principles of the AEE (based on HAPUA/AEMI's April 2017 workshop), before providing a brief introduction to selections from the academic literature, as well as the main regional electricity market initiatives that are analyzed in this thesis. This provides the context for the analysis in the next chapter, where features of these regional power markets that are relevant for the AEE initiative will be identified.

5.1 HAPUA/AEMI's Proposed Structure for the AEE

As previously mentioned, the AEE is currently in its feasibility phase; hence, the APGCC has yet to determine an approach for its implementation, and there are no concrete plans for its organizational structures, features, and trading mechanisms. However, HAPUA is not entering this process blind – certain core principles have already been identified to serve as a guide for the process of achieving the AEE. This has been discussed in Chapter 4, but is worth mentioning again here: First, the AEE will be implemented on a step-wise and voluntary basis, trading only surplus excess generation capacity to meet demand gaps. Second, it should not require complete regulatory harmonization; rather, only a "core level of coordination" should be required for the purposes of cross-border trading. However, what this "core level of coordination" is has yet to be defined. Third, there should be transparent pricing

mechanisms for the power exchange to function in a "predictable and efficient manner" – transit pricing should be agreed upon in the AEE's early stages as part of this process (AEMI, 2017a).

In addition to these core principles, the AEE's feasibility study outline has also proposed certain features for the power exchange – these include recommendations such as utilizing the Day-Ahead Market (DAM) as the mechanism for power trading; that certain congestion management structures and dispute settlement mechanisms be put in place; as well as the suggestion that an independent regional exchange (market) operator be created (AEMI, 2017b).

What do these core principles and proposed AEE features in the AEE's feasibility study mean? They were identified based on the conclusions of HAPUA's April 2017 forum, which brought together experts from different regional power sector integration projects to discuss common success factors. However, the feasibility study itself is intended to serve as a platform for ASEAN policy-makers to agree upon the AEE's design components as well as its road-map for development. Hence, it seems that these principles and features are not set in stone, and should be understood instead as a rough guide for the AEE's conceptualization – to be added to or amended based on the result of further studies. In fact, the forum's concept note itself also states that further details of these principles were to be worked out as part of the feasibility study process (AEMI, 2017a). This chapter aims to do just that, by adding more substance to the AEE's proposed structures and approaches, through identifying certain core principles that drive the functionality of other regional electricity exchanges.

Within this context, the AEMI-HAPUA-ESCAP workshop has proposed a useful framework for analysis, based on certain key components that would determine its functionality:

(a) Degree of market integration and regional power trading
(b) Regional institutions and governance structure

(c) Technical, economic, regulatory, and legal harmonization

(d) Roles of regulators and Transmission System Operators (TSOs)

(e) Degree of market liberalization and restructuring across region

(f) Measures to ensure sustainability, including to increase the share of renewable energy

(g) Mechanisms for infrastructure development and financing

5.2 Other Examples of Regional Electricity Exchanges around the Globe

In keeping with the objective of this thesis – to identify key lessons that are relevant for the ASEAN Power Grid (APG) project from the experiences of regional power sector integration initiatives around the world – the literature review forms a key component of the research. There exists a wealth of academic work that has been done on the different aspects of multilateral power trading, covering a wide range of cross-border power interconnections and regional grids. This section introduces the scope of this study, and gives a brief overview of a selection of the regional electricity exchanges covered in the academic literature review. The findings drawn from these academic studies are utilized for the analysis in the next section.

5.2.1 Scope of analysis: Which academic studies were covered?

This thesis draws its findings from a range of academic literature focusing on regional power sector integration around the world. However, while these papers tend to focus on regional power connectivity in a broader sense, this thesis focuses specifically on regional electricity exchanges – in terms of their structures, features, and implementation approach. Engaging in extensive comparative analysis of these projects could help to uncover important success factors and lessons, which can then be applied to the APG.

Some of the studies approach this subject by focusing on a single regional grid, while others engage in a comparative analysis of power connectivity in multiple regions. However, two reports stood out for their breadth of coverage and depth of analysis – since the analysis in this thesis drew heavily from them, they will be introduced in greater detail here:

- **World Bank ESMAP Report:** *Regional Power Sector Integration – Lessons from Global Case Studies and a Literature Review* (ESMAP, 2010c)

The Energy Sector Management Assistance Program (ESMAP) is a World Bank Group initiative aimed at helping low to middle-income countries with poverty reduction and economic growth, using environmentally-sustainable energy solutions.

Recognizing both the benefits and the challenges of regional power sector integration projects (RPSI) in developing countries, ESMAP conducted an 18-month study aimed at "demonstrating what has and has not worked in different regions around the world." The objective of the project was to present key findings, guidelines, and ultimately strategic solutions, to help practitioners involved in electricity market integration projects. In this respect, the ESMAP report's goals are exactly aligned with those of this thesis.

The report is broken into three major components: the first is a literature review conducted by Economic Consulting Associates, which summarizes the findings from more than 80 different reports and publications relevant to RPSI in the 12 case studies that the World Bank had identified. The second delves deeper into each case study in greater detail, identifying the motivations for power connectivity, the mechanisms of trade and institutional arrangements, as well as the various challenges faced. The third component then summarizes the main lessons drawn from both the academic literature as well as global experience with RPSI. The 12 case studies identified encompass both regional markets and cross-border power projects:

- Central American Electrical Interconnection System (SIEPAC)
- Greater Mekong Sub-region (GMS)
- Gulf Coast Countries (GCC)
- Nile Basin Initiative (NBI)
- Pennsylvania-New Jersey and Maryland Interconnection (PJM)

- South East Europe (SEE)
- Southern Africa Power Pool (SAPP)
- Union for the Coordination of the Transmissions of Electricity/European Network of Transmission System Operators for Electricity (UCTE / ENTSO-E)
- Argentina-Brazil (Garabi Project)
- Cahora Bassa
- Manantali
- Nam Theun 2 (NT2)

For the purposes of this thesis, the four cross-border projects are excluded from the analysis. In addition, some of the case studies (eg. GCC; NBI) do not feature power exchanges, and hence, are also excluded.

The World Bank report provides sufficient depth and extensive breadth, critically analyzing the findings of the existing literature and of international experience using a comparative framework. The relevant conclusions from the study will be analyzed and discussed in the next chapter.

- **SARI/EI Background Paper:** *Cross-Border Electricity Trade in South Asia – Key Policy, Regulatory Issues/Challenges and the Way Forward* (Parikh, Kharbanda, & Panda, 2016)

The South Asia Regional Initiative for Energy Integration (SARI/EI) is a USAID- sponsored program which aims to strengthen energy security in South Asia, through enhancing cross-border energy trade (CBET). The initiative, which began in 2000, covers eight countries – Afghanistan, Bangladesh, Bhutan, India, The Maldives, Nepal, Pakistan and Sri Lanka. In 2016, a workshop on *Sustainable Development of Power Sector and Enhancement of Electricity Trade in the South Asian Region* was conducted in New Delhi, where the SARI/EI program secretariat presented a background paper on cross-border electricity trading. The objectives of this study are to take stock of the current context, progress, and challenges of power connectivity in

South Asia, before analyzing international experiences in CBET to identify critical success factors. This study was especially useful as it summarized the major milestones and key instruments of CBET in various regions of the world:

- Greater Mekong Sub-region (GMS)
- Southern Africa Power Pool (SAPP)
- West African Power Pool (SAPP)
- Central American Electrical Interconnection System (SIEPAC)
- Nordic Pool

Again, the key findings will be analyzed and discussed in the next chapter.

5.2.2 Which regional electricity exchanges?

Based on a review of the academic literature, this thesis draws lessons from the experiences of various regional power exchange initiatives around the world. This sub-section provides a background on the main regional power exchanges that were considered, which include: the Nordic Pool, the Southern Africa Power Pool (SAPP), the West African Power Pool (WAPP), Mercado Eléctrico Regional in Central America (MER), and Europe's various sub-regional power exchanges (e.g. EPEX spot). In addition, although the U.S. power exchanges are mostly domestic, they are also included in the analysis, as competitive electricity trading platforms that transcend state jurisdictions tend to face challenges that are similar (though less significant) to those of transnational regional power exchanges initiatives. Of course, the following list is not exhaustive of all the regional power exchanges covered in the academic literature, or in the analysis of this thesis – a full summary can be found in **Appendix A.**

a. Nord Pool

- Countries covered:

Norway; Sweden; Finland; Denmark; Germany; Latvia; Lithuania; Estonia; the United Kingdom.

In addition, Nord Pool Spot has also been appointed the Nominated Electricity Market Operator (NEMO) in 14 different European countries, and it jointly operates the Bulgarian and Croatian power markets with *IBEX* and *Cropex*, respectively.

- Year of inception:

1996. A joint Norwegian-Swedish power exchange was established, which would eventually become the Nord Pool ASA.

- Rationale/Approach:

The inception of the Nord Pool regional exchange was caused by over-investment, and hence, overcapacity of hydropower production in Norway. The realization that market distortions led to conditions of overinvestment created a push for domestic power market liberalization in Norway, while the overproduction of power was the catalyst for the opening up of electricity trade with Sweden (Bredesen & Söderström, 2016). Subsequently, other Nordic countries begin to join the regional power exchange.

- Volumes of traded power:

In 2013, the volume of electricity traded on the Nord Pool Spot's DAM was 348.9 TWh, accounting for 88% of Nordic consumption (NordReg, 2014a).

- Market mechanisms:

The commercial arrangements of the Nord Pool are highly advanced. The *Nord Pool Spot* operates both physical and financial markets. Physical trades are conducted through both the day-ahead and intra-day markets,

while *Elbas* was created in 2004 as a separate balancing market for physical trades. In addition, electricity commodity derivatives are traded on the *UK N2EX* power market.

- Structure:

Nord Pool is jointly owned and operated by the national transmission system operators of the participating countries in the Nordic and Baltic regions.

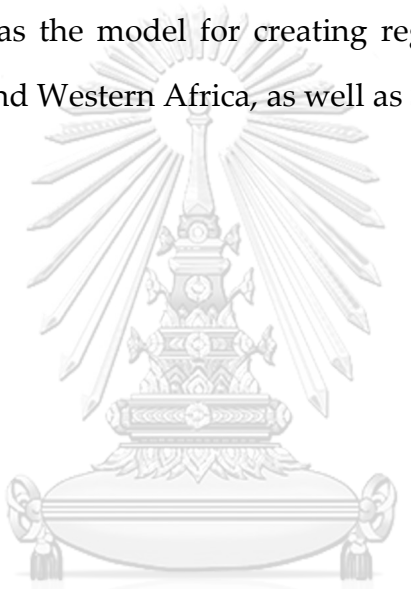
- Assessment:

The Nord Pool is unanimously considered to be the most successful regional power exchange that exists today. While Oseni and Pollitt (2014) do not include the Nord Pool model as part of their case studies, they state that it is the most successful power market model in the world. The high level of integration is seen from the fact that the volume of electricity traded on the Nord Pool Spot makes up a high proportion of Nordic consumption (Ray and Jain, 2016). The physical infrastructure is also relatively well-developed – even as early as 2000, cross-border transmission capacity was between 10 - 31% of domestic electricity production capacity for the countries in Nordel (Pineau, Hira, & Froschauer, 2004).

Today, the Nord Pool spot trading region covers the Nordic and Baltic states, and is in the process of being integrated with adjacent regional markets as part of the vision to create a pan-Europe electricity market. According to Ray and Jain (2016), there is strong regulatory coordination between the Nord Pool countries: NordREG was created as the forum for the national regulators to cooperate on a regional level. In addition, the

TSOs of the Nordic and Baltic countries jointly own Nord Pool Spot AS, which provides a reference price and acts as a "neutral and reliable power-contract counterparty to market participants" (Ray & Jain, 2016). Apart from these operations, the TSOs also cooperate in long-term market development from a regional perspective, to ensure the security of electricity supply.

The success of the Nordic Power Pool is also evident from the fact that it has been used as the model for creating regional power exchanges in Southern Africa and Western Africa, as well as South Asia.



b. Southern Africa Power Pool (SAPP)

- Countries covered:

12 Countries (Angola, Botswana, Democratic Republi of Congo, Lesotho, Mozambique, Malawi, Namibia, South Africa, Swaziland, Tanzania, Zambia, Zimbabwe)

- Year of inception:

1995. Energy Ministers in the region signed an inter-governmental MOU for the creation of the SAPP.

- Rationale/Approach:

The drought experienced in the Southern African region in 1992, which resulted in severe electricity shortages due to reduced hydro-electricity generation, highlighted the need for regional power cooperation to be formalized. The uneven distribution of power resources in the region provided the impetus for regional cross-border electricity exchange among the countries of the region – there exists large hydroeleectricity reserves in the Northern part (especially the Inga Reservoir in the Democratic Republic of Congo and the CahoraBassa Reservoir in Mozambique), as well as signficant coal resources in South Africa (O'Leary, Charpentier, & Minogue, 1998).

The market underwent two phases of development: the infrastructure was first developed on the basis of long-term bilateral deals, before surplus generation capacity was available for short-term "opportunity trading" in recent years (Castalia, 2009).

- Volumes of traded power:

1,059,540 MWh (2015-2016), accounting for 14% of total trades, and 10% of region-wide electricity demand (SAPP, 2016).

- Market mechanisms:

The day-ahead market (DAM) and balancing market are both operational, and the SAPP is currently preparing to launch its the intra-day and forward future markets. In addition, the MW-KM approach is used for transmission pricing, but the SAPP is currently studying the feasibility of implementing the Nord Pool's nodal pricing model.

- Structure:

Regional Electricity Regulators Association of Southern Africa (RERA) was set up in 2002, made up of the SAPP's national regulators. However, RERA does not have authority in regulatory matters; it functions as a coordination platform for national regulatory agencies.

Instead, market operation and regulatory issues are determined by various SAPP committees, based on equal representation for participating national utilities. Chairmanship of these committees is rotated between the various representatives (ESMAP, 2009b).

- Assesssment:

Despite the relatively mature operational procedures, the main barrier to market development in the SAPP has been its transmission interconnector constraints, in the face of rising electricity demand (Castalia, 2009; Oseni & Pollitt, 2014). The World Bank (2010) also points out that the harmonization of rules, regulations and grid codes in the SAPP is lacking.

c. Western Africa Power Pool (WAPP)

- Countries covered:

14 Countries (Gambia, Senegal, Mali, Burkina Faso, Niger, Guinea-Bissau, Guinea, Sierra Leone, Liberia, Côte d'Ivoire, Ghana, Togo, Benin, Nigeria)

- Year of inception:

In 2000, ECOWAS Ministers of Energy adopted an Intergovernmental Memorandum of Understanding (MoU) on the establishment of WAPP.

- Rationale/Approach:

West Africa holds roughly one-third of the continent's fossil fuel reserves; yet, over half of its population still lacks access to electricity. Hence, the WAPP was envisioned to pool together electricity resources in order to increase the stability and reliability of electricity supply in the region – at competitive costs (Cheto & Brooks, 2013).

- Volumes of traded power:

None. Cross-border power flows within the WAPP are currently based on bilateral or multilateral agreements.

- Market mechanisms:

At present, there is no competitive trading through the regional power exchange. Trading arrangements in the WAPP is planned first be implemented through long-term contracts, with the allocation of excess production among members, before the eventual development of spot market energy trading later on (Oseni & Pollitt, 2014).

- Structure:

Based on the WAPP's Inter-governmental MOU, the 14 countries were split into two zones – Zone A includes countries with interconnected systems, while Zone B includes countries with underdeveloped interconnections.

The General Assembly of the WAPP comprises representatives from all member states. It is the highest decision-making body, and is responsible for adopting measures to facilitate the implementation of the WAPP's principles and projects. The General Assembly also elects the Executive Board, which is tasked with implementing initiatives to achieve the WAPP's goals. Various organizational committees, made up of technical experts selected from WAPP members, support the Executive Committee in its work (Oseni & Pollitt, 2014).

- Assessment:

WAPP is assessed to have made slow progress in terms of market integration – there has been almost no regional trading activity after over a decade. In contrast to the deeper integration achieved by the SAPP, the limited capacity of existing infrastructure has served as a significant constraint for market integration (Oseni & Pollitt, 2014). However, Castalia Strategic Partners (2009) argues that in terms of its decision-making framework, the WAPP secretariat is more empowered than that of the SAPP, and hence, is able to speed up the implementation process for priority projects. This observation was made at a time when the SAPP was struggling to agree on a power pool plan. However, the SAPP has since successfully launched its DAM in 2009, while the WAPP continues to lag behind.

d. Mercado Regional de Electricidad (MER) – Central America

- Countries covered:

Six countries (Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua and Panama)

- Year of inception:

1997. The six Central American countries signed the *Central American Electricity Market Framework Treaty*, for the creation of a regional competitive market (Rodriguez, 2017).

- Rationale/Approach:

The region contains untapped energy reserves, particularly in hydropower. However, large-scale development is hamstrung by small markets at the individual country level and a lack of sufficient market integration. Achieving economies of scale in generation is only possible in the context of a multinational market (ESMAP, 2010a).

Power sector organization varies widely across the six Central American countries. Hence, the MER was established as the seventh market, superimposed on the other six national markets. Regional regulation enables the Regional Operating Agency (EOR) to perform international electriciy transactions in the region (Oseni & Pollitt, 2014). The MER's design deliberately seeks to allow the individual countries the ability to develop domestic electricity sectors at their own pace, while also facilitating intra-regional trade (ESMAP, 2010a).

The SIEPAC transmission line project was constructed in order to stimulate competitive trading in the MER. The line connects all six member countries, and has a capacity of 300 MW – equivalent to 5% of Central America's total demand (Prada et al., 2004).

- Volumes of traded power:

Cross-border flows account for less than 5% of regional electricity consumption. Of this, spot trading made up only 5.85% of total trades in 2010, and 1.6% in 2011 (Oseni & Pollitt, 2014).

- Market mechanisms:

Commercial integration has been achieved through day ahead markets, a real-time balancing market, and capacity auctions (IEA, 2016). Transmission charges are based on nodal pricing.

- Structure:

To support market operations, the regional regulatory commission, *CRIE* (*Comisión Regional de Interconexión Eléctrica*), the regional system operator, *EOR* (*Ente Operador Regional*), and the company that owns the grid, *EPR* (Empresa Propietaria de la Red), were created (Oseni & Pollitt, 2014). Both the *CRIE* and the *EOR* comprise of representatives from each member country, to ensure that each country has inputs in both regulation and the day-to-day market operations. The interconnectors are 75% publicly owned by the utilities and transmission companies of the six member states, with the remaining 25% coming from private sources, including from the Spanish company, *ENDESA* (Prada et al., 2004).

- Assessment:

The MER is an example of cross-border cooperation in a region where there is a huge range in terms of the level of domestic market liberalization (Oseni & Pollitt, 2014). Despite this, the MER exhibits a relatively high level of regulatory integration. One of the first steps of the MER was to establish a regional regulator, a regional system operator and a transmission owner (Castalia, 2009). In essence, the superimposition of the

regional market over the six national markets that it encompasses allowed domestic utilities that were at various stages of vertical integration and privatization to trade effectively with each other. This was facilitated by a high degree of institutional harmonization, as national regulators coordinate common market rules and implement MER codes amongst themselves, which in turn determine the regulatory frameworks for national system operators concerning dispatch, tariffs and transmission services (Fedosova, 2015). In addition, the MER also has in place a dispute resolution mechanism for market players (Castalia, 2009).

The SIEPAC line project, which connects all six Central American countries, has significantly improved the infrastructural integration of the region's electricity markets (Fedosova, 2015). In addition, there a separate pricing mechanism was created for countries such as Honduras and Costa Rica, which have no competitive national electricity prices, to accomodate their participation in the regional market (Fedosova, 2015).

While commercial integration has been achieved through various market-based mechanisms, volumes of cross-border flows are still very limited; and even these are predominantly conducted through bilateral agreements rather than competitive exchange (Oseni & Pollitt, 2014). There are also other challenges to the regional market's further development – the region is characterized by the prevalence of subsidies and price controls, which distort the market (Fedosova, 2015). In addition, the region's aging power generation and transmission infrastructure must be addressed before further power market development can occur (IEA, 2016).

e. North America

North America has a relatively complex elctricity market. Cross-border power trading between the U.S. and Canada is relatively advanced, but occurs through four domestic electricity exchanges in the U.S. (namely; Northwest ISO, Midcontinent ISO, New York ISO, and ISO New England). In contrast, transmission connections between the U.S. ERCOT market and Mexico are asynchronous.

The North American market is made up of 10 different RTOs and ISOs (FERC, 2017). Most of these power exchanges cut across multiple U.S. state jurisdictions. Recently, there has been some effort to increase cooperation and coordination between the RTO/ISOs – since 2008, PJM and MISO have engaged in a *joint operation agreement*, while ISO-NE, NYISO, and PJM have also been part of the *Northeast ISO/RTO Planning Coordination Protocol* since 2004.

This sub-section will focus on the PJM RTO as an example of a North American power exchange, as it is the 'oldest, largest, and arguably most developed' interstate electricity trading area in the US (Oseni & Pollitt, 2014):

- States covered:

  One country; 13 state jurisdictions (Delaware, Illinois, Indiana, Kentucky, Maryland, Michigan, New Jersey, North Carolina, Ohio, Pennsylvania, Tennessee, Virginia, and West Virginia), *in addition to* the District of Columbia.

- Year of inception:

1997. In April that year, PJM opened its first bid-based energy market. That same year, the Federal Energy Regulatory Commission (FERC) approved the designation of PJM as the nation's first fully-functioning independent system operator (ISO) (PJM). In 2002, PJM became the nation's first fully-functioning RTO.

- Rationale/Approach:

The origins of power trading in PJM can be traced back as early as 1927, when three utilities decided to form a power pool to realize the benefits and efficiencies of sharing power generation resources (PJM). More market players subsequently joined, as the geographical scope of the pool's activities also expanded.

- Volumes of traded power:

PJM's transmission volumes for 2016 were 830 TWh (PJM, 2016). That year, PJM was a net importer of electricity from other regional systems, with a total net interchange of -9,182.4 GWh in the DAM (PJM, 2017).

- Market mechanisms:

Within PJM, trades can be made on the DAM, as well as real time energy, capacity, and transmission rights markets (Oseni & Pollitt, 2014).

PJM market participants also import electricity from and export electricity to external regions continuously, with interface pricing mechanisms applied between PJM and other ISO/RTOs.

- Structure:

Just as with other ISO/RTOs in the U.S., the Federal Energy Regulatory Commission (FERC) regulates PJM, and approves its open access transmission tariffs.

PJM is a not-for-profit entity, and is owned by its participating member utilities. US ISO/RTOs have fully independent boards, made up of individuals that do not have any ongoing relationship with market participants. This is in contrast to the other regional power exchanges, where regulation and planning is conducted by committees that include representatives from each participating utility (Oseni & Pollitt, 2014).

- Assessment:

PJM's market mechanisms are well-developed in terms of product offerings and market features. However, the World Bank (2010) points out that its pricing mechanism (locational marginal pricing) does not provide the necessary returns required to incentivize infrastructure investments to reduce grid congestion.

Despite the relatively high levels of market integration within the respective US interconnections, there is relatively limited transmission capacity *between* them – almost negligible when compared to the interconnection capacities *within* them. The main challenge has been that these interconnections cut across multiple system operation jurisdictions. However, efforts are being made to increase the level of coordination between ISO/RTOs. At the direction of FERC, PJM and MISO have engaged in a joint operation agreement since 2008, while ISO-NE, NYISO, and PJM have also engaged in the Northeast ISO/RTO Planning Coordination Protocol since 2004. FERC Order 1000 also requires regional

planning authorities to exchange data annually, and to harmonize their decision-making processes (Baritaud & Volk, 2014).

In North American power market more broadly, "cross-border coordination is sometimes greater than subregional coordination within a specific country." North-South integration between the US and Canada surpasses East-West power trading between different states or ISO/RTOs within each country. This is helped by the fact that investment decisions in North America also enjoy more regulatory certainty (Castalia, 2009). However, cross-border transmission between the US and Canada are already at full capacity, which poses a barrier to the deepening of integration (DOE, 2017).

f. European Union

The European single market project began in 1986, with the vision of creating a single European electricity market. As part of this project, multiple regional electricity trading blocs exist (and are being developed) within the EU, which include: the Nordic region including the Baltic republics, Northwestern and Central Europe, the Iberian Island, and Southeast Europe (Egenhofer & Genoese, 2016).

Compared to the ISO/RTO experience of North America, European power exchanges are more diverse in terms of scope, coverage, and maturity. This sub-section focuses on the European Power Exchange (EPEX Spot), as it operates across national markets that account for 50% of European electricity consumption. The EPEX Spot functions as the platform for physical power trading, while the European Energy Exchange AG (EEX AG) supplements this with the operation of financial derivative markets. However, the latter will not be discussed in this chapter.

- <u>Countries covered</u>:

Eight countries (Germany, Austria, Luxembourg, the United Kingdom, France, the Netherlands, Belgium and Switzerland).

- Year of inception:

2008. EPEX Spot SE was created through the merger of spot trading activities between Powernet SA, based in France; and EEX AG, based in Germany (EPEX).

- Rationale/Approach:

The development of the EPEX Spot has been built up from the merger of the French and German domestic power exchanges, with the fundamental goal to achieve Europe-wide power market integration. Austria joined the market area in 2012, followed by Switzerland in 2013 (Fedosova, 2015).

EPEX Spot has also developed its trading mechanisms on a step-wise basis; for example, intra-day trading mechanisms became opeational in France and Germany in 2010 first, before being launched in Austria in 2012, and subsequently in Switzerland in 2013. In addition, new market mechanisms are gradually developed and rolled out (EPEX, 2017). However, on a more macro level, spot market trading has also been facilitated by EU-wide energy directives (in 1996, 2003, and 2009), which mandated domestic certain energy market reforms, and ensured open access to transmission lines.

- Volumes of traded power:

565,760,085 MWh of traded power in 2015, accounting for 53% of region-wide elecctricity consumption (EPEX, 2017).

- Market mechanisms:

DAM and Intra-day markets. The EPEX Spot also has market coupling arrangements to facilitate electricity flows across the EU's power trading regions.

- Structure:

The EPEX Spot market is subject to three levels of regulation. The EPEX Spot exchange itself is incorporated in France, and coordinates market operations for trading. Within the EPEX Spot, market participants make up the independent committees that supervise regulation and market operations.

However, domestic power markets in Europe are also subject to some level of EU-wide regulation. The EU has the supra-national authority to mandate domestic market reforms, and also wields strong enforcement mechanisms. Hence, the EPEX Spot benefits from EU-level directives aimed at domestic power liberalization, as well as EU regulations that mandate open access to transmission lines. In addition, EPEX Spot's regulatory frameworks as well as "issues of network development coordination" are addressed by the European Network of Transmission System Operators for Electricity (ENTSO-E), Europe's supranational regulatory agency for electricity markets.

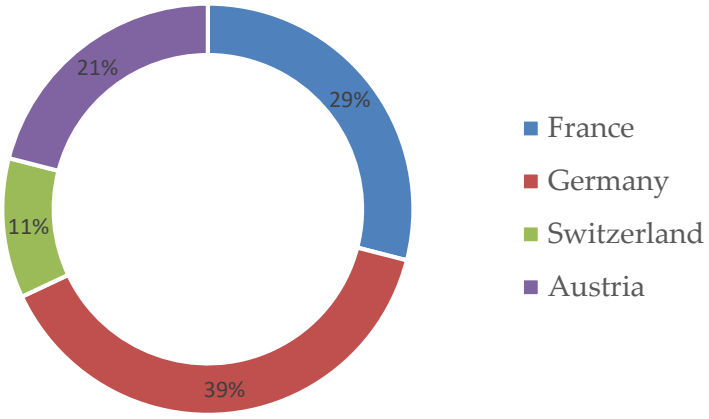
All other issues, such as market coupling and security of supply, are addressed by the *Pentalateral Energy Forum*, which is made up of electricity market regulators from participating member countries (Fedosova, 2015).

In terms of ownership, EPEX Spot is jointly owned by its member TSOs through joint subsidiaries – EEX Group holds 51% of its equity, while HGRT owns the remaining 49% (EPEX). EPEX Spot itself also holds 25% ownership share of the South Eastern European Power Exchange (SEEPEX) (EPEX, 2017).

- Assessment:

Infrastructural integration within the EPEX Spot zone is assessed to be high, but varies across borders. As expected, cross-border transmission capacity directly impacts the level of each country's participation in EPEX Spot. For example, Switzerland, the most recent member to join the trading area, only accounted for a small percentage of cross-border power flows in 2013, due to a lack of cross-border connections (Fedosova, 2015), as shown in **Fig. 9**:

Fig. 9: Participating Country Shares in Cross-border Electricity Exchange, 2013



Source: Fedosova, 2015

Transmission infrastructure projects is currently being developed to address bottlenecks in power trading within the EPEX Spot, with the responsibility and costs "divided between countries according to the territory of lines and transformers' location" (Fedosova, 2015).

Just as in Central America, the Central Western Europe countries that make up the EPEX Spot market also exhibit a high level of diversity in terms of the organization of domestic power markets, as well as the level of market liberalization. For example, *Electricité de France* exists as France's vertically-integrated, state-owned monopoly; in contrast, the power sector in Austria is vertically-unbundled (Fedosova, 2015). This suggests that although the EU has wide-ranging authority within national power markets, the level of EU-wide electricity regulations have been rather limited – for example, under the 2009 EU

directive on internal electricity markets gave member states a choice between ownership unbundling, and setting up and independent system operator transmission operator (EU, 2009). As can be seen, supranational EU authority has been largely used to ensure cross-border harmonization for power sector trading, as well as achieving the minimum level of domestic market reforms necessary to achieve this.

Chapter 6:
Analysis – Lessons for the AEE from International Experience

The previous chapter provided a brief introduction to the academic literature utilized in this analysis, as well as some of the regional power exchanges that they studied. This chapter aims to leverage on the experiences of these regional power exchange initiatives, in terms of their structures, features, and the various approaches for their implementation. The ultimate goal of this chapter is to suggest a viable approach for the creation of the ASEAN Electricity Exchange, and to recommend certain features or structures for it to function – grounded within a Southeast Asian regional context.

6.1 Design Elements for the Creation of a Regional Electricity Exchange

Based on a comparative analysis of the experiences in different regions around the globe, this section identifies the **pre-requisites** for creating such a regional power exchange, as well as its necessary **structures** and **trading arrangements**. In addition, the **implementation approaches** of these regional initiatives are also considered. As mentioned in the previous chapter, this thesis adopts a looser definition of "region", to include electricity exchanges that encompass multiple state jurisdictions located within a single country. These findings will form the basis for the proposed policy recommendations for the AEE initiative, which will be covered at the end of the chapter (**section 6.4**).

6.1.1 Pre-requisites for the Creation of a Regional Power Exchange

The existing academic literature supports the fundamental assumption in this thesis – that the creation of a competitive regional power exchange *does not* require complete domestic market liberalization, including the vertical unbundling and privatization of national electricity utilities. However, this sub-section explains that there are minimum electricity market reform steps that must be adopted to facilitate competitive power trading:

(a) Vertical unbundling and privatization of domestic utilities is *not* a pre-requisite

Breaking up of the monopoly power of vertically-integrated domestic power utilities is crucial for introducing competition into domestic power markets (IEA, 2005; Kessides, 2012). It is also traditionally viewed as one component of the "textbook model" of electricity market reform (Sen, Nepal, & Jamasb, 2016). However, liberalization through vertical unbundling of the domestic power industry is *not* a pre-requisite of cross-border power trading. Within the Nordic, European, and Central American power markets, competition within the regional wholesale spot markets was not hindered by the presence of vertically-integrated companies in some countries (Pineau, et al., 2004 & Fedosova, 2015).

Bredesen (2016) also supports this view, pointing out that full market liberalization and ownership unbundling do not need to happen from the start as a prerequisite for market integration – these reforms should be implemented in a gradual, stepwise process. He cites the case of the Sothern African Power Pool, where the regional market functions even though some domestic markets are still structured based on single buyer or seller models. However, Bredesen does concede that vertical unbundling was crucial to the success of the Nordic regional market. He states that all the Nordic member countries followed the same process of unbundling and had similar market structures, which explains why integration into the Nord Pool market was relatively smooth. Bredesen's views are echoed by the findings of the World Bank ESMAP project on Regional Power Sector Integration (2010), which show that deeper levels of regional power sector integration can only be achieved if the respective national markets are at similar stages of reform. Singh, et al. (2015) suggest that the logic may work in the opposite direction instead – developing regional electricity trade may conversely help improve competition in domestic markets, and bolster domestic market reforms (Singh, Jamasb, Nepal, & Toman, 2015).

There is also an important distinction to be made between regional power exchange models at different levels of trading and integration – in more limited power exchange structures where only surplus electricity capacity is traded, the presence of monopolies in the various domestic power sectors has a more limited impact on the functioning of the regional power exchange, as long as these national monopolies do not also dominate the regional electricity market. This is seen in multiple case studies – in SAPP, vertically-integrated national utilities where the founding members of the power pool, and independent power producers were only allowed to join the pool later on (Rose, 2015). In addition, the MER also encompasses domestic electricity markets that remain vertically-integrated (ESMAP, 2010c).

(b) Third-party access to transmission lines is necessary for the regional power market to function

While full domestic liberalization of the domestic power sector is not required for regional electricity market integration, power trades cannot occur without open access to transmission infrastructure. EU regulation ensures non-discriminatory access to the regional grid, while the ISO/RTOs within the US regional power markets have the responsibility to enforce this (Oseni & Pollitt, 2014). The regional grid company in Central America was also created to ensure open access to the SIEPAC line (Fedosova, 2015).

Here, it is important to note that Third Party Access (TPA) cannot apply only to cross-border transmission infrastructure, but should also extend to the various national grids. This is because physical electricity trades between two jurisdictions that are not adjacent to each other may be possible only by transiting through a third jurisdiction.

(c) Some types of domestic electricity subsidies *must* be removed

There is some disagreement among academics on the need to achieve transparent price signals in the domestic market before engaging in international electricity trading. Oseni and Pollitt (2014) state that in regions with a history of

domestic energy subsidies, cross-border integration would worsen these market distortions, and in effect decrease overall welfare. However, the case study of the MER shows that this is not true – Honduras and Costa Rica, do not have competitive domestic electricity prices, but the MER is still able to put in place a mechanism for border pricing for power trades (Fedosova, 2015).

While all power sector subsidies are inherently market-distorting, it is important to distinguish between consumer- and producer-side subsidies for the purposes of the APG project. Direct consumer subsidies effectively inflate electricity consumption by hiding the real cost of electricity from end-users. However, these are not prohibitive for cross-border power trading – regardless of the prices that consumers pay for electricity, domestic power utilities or distribution companies would still have strong incentives to import electricity if the cost of domestic generation is higher. In contrast, producer-side electricity subsidies *are* potentially prohibitive to cross-border trading – when domestic power generation companies are subsidized, foreign electricity imports become uncompetitive even if they would potentially increase consumer surplus by utilizing lower-cost generation. Here, it should be noted that the market-distorting impacts of producer- and consumer-side subsidies are similar for both fully-integrated competitive regional electricity market models and more limited power exchange models where only excess capacity is traded.

Unfortunately, while the removal of producer-side subsidies is crucial for the functioning of a regional electricity exchange regardless of its form or structure, such reforms are not always politically expedient; they tend to be related to the larger issue of protectionism of state-owned or state-linked power sector companies in Southeast Asia due to the politics of power markets, which has already been discussed in **Chapter 3**.

(d) A minimum level of physical transmission infrastructure is crucial for market creation

Regional transmission infrastructure *does not* have to be fully developed to allow for competitive power trading, but the lack of transmission capacity and coverage will impede later stages of deeper market integration. Insufficient cross-border transmission capacity is a significant barrier to market integration, as it creates a bottleneck to power flows (Oseni & Pollitt, 2014). This is true even in the relatively mature EU regional power market, where the realization of cross-border trading is limited by the existence of physical transmission infrastructure. Oseni and Pollitt (2014) compare the development of the SAPP and the WAPP, suggesting that the WAPP's relatively slow progress beyond bilateral trading is due to a lack of transmission capacity. This view is shared by Castalia Strategic Advisors (2009). Considering the case studies of MER and SAPP, Oseni and Pollitt also conclude that the lack of transmission capacity has not prevented the emergence of spot markets, but severely limits their significance and explains the prolonged dominance of bilateral trading. In the SAPP, 20% of energy that was matched on the SAPP's (2015/2016) could not be traded due to transmission constraints, which was an increase from 12% the previous year (SAPP, 2016). The importance of physical infrastructure is also evident from the fact that the SIEPAC transmission line project, which greatly expands cross-border electricity connections across all six MER participating countries, has formed an integral part of the MER vision of a regional power exchange.

6.1.2 Regional Structures for Regional Power Markets

Regional institutions are crucial for the regulation and operation of a regional power exchange, but there is no one specific institutional structure that should be utilized (ESMAP, 2010c) – these should be adapted to the needs, goals, and context within each region. In creating a competitive regional power exchange, member states from each regional bloc need to decide how these regional institutions should be structured to best address **market regulation**, **market operation**, as well as **regional power sector planning**. This sub-section discusses the types of institutions that exist in various regional power exchanges today, and identifies the minimum

level of institutionalization (if any or determinable) required for the exchange to function:

- Regional regulatory structures

In all regional electricity exchanges covered in the analysis, regional regulatory bodies are made up of the domestic regulators from participating countries. This ensures equal representation from all countries involved. For some regional regulatory bodies, such as the Nordic Energy Regulators (NordReg) in the Nordic Pool and Comisión Regional de Interconexión Eléctrica (CRIE) in Central America's power exchange, chairmanship is rotated amongst its members to minimize conflicts (NordReg, 2014b; Oseni & Pollitt, 2014).

Even so, that the regional regulatory body has any authority in regional regulation or enforcement is not a pre-condition for the regional electricity market to function. This is evident from the fact that the SAPP continues to operate even though the Regional Electricity Regulators Association of Southern Africa (RERA) has no market regulation authority; instead, it remains as an association of national regulators created for the purpose of capacity building, information sharing, and facilitating regulatory harmonization of electricity sector policy, legislation, and regulations to achieve cross-border trading. In fact, RERA does even not fall within the SAPP's institutional framework, but liaises and coordinates with the SAPP's governing institutions (ESMAP, 2009b).

Despite this, a supranational body with regulatory authority in the regional market is useful to prevent market distortions – Oseni and Pollitt (2014) argue that some regulatory oversight may have prevented or mitigated the potentially predatory pricing behavior of South Africa's public electricity utility, *Eskom*.

Ultimately, the powers granted to regional power sector regulatory bodies (if any), is determined by a range of interacting factors: First, the intended model of power exchange is important. For power exchanges that trade only surplus generation capacity, regional regulatory institutions do not need to have authority

over the domestic power sector of participating countries. This is shown in the case of Central America's MER, where the regional market superimposes over the six national electricity markets (Oseni & Pollitt, 2014). While there is a relatively high level of regulatory integration within the MER, the regional regulatory, CRIE, has no authority over domestic power markets.

Second, intra-national power markets, unsurprisingly, tend to be able to delegate more authority to regional regulatory bodies as compared to transnational exchanges. This is primarily because it is easier to grant national-level regulatory powers to a national agency, but countries tend to be unwilling to allow transnational institutions from having the authority to intervene in domestic markets. In the US, FERC is the independent national agency that regulates the interstate transmission of electricity. Hence, it holds regulatory authority over all RTOs and ISOs, with the exception of the Electricity Reliability Council of Texas (ERCOT), as ERCOT is not synchronously connected to the rest of the United States. Similarly, Australia's national energy regulator (AER) was established as the single independent regulatory agency responsible for the National Electricity Market (NEM), superseding the authority of 13 state-level regulators. This was important for regional power market integration in the NEM, as it avoided the potential for any jurisdictional bias between states when market-wide decisions are made (Baritaud & Volk, 2014). The experience of transnational regional exchanges has been starkly different – while some regional power exchanges have regulatory institutions that hold authority over the regional market, none has legislative or executive powers to intervene in the domestic sectors of participating countries.

However, the delegation of regulatory authority to a regional body should be viewed on a spectrum. It is still possible for regional institutions to have some limited powers of enforcement where there is strong political commitment by member states to deepen power sector integration. This is seen in the MER, which has the authority to enforce resolutions in market disputes (Castalia, 2009).

Third, where there pre-exists a high degree of regulatory harmonization among participating member states within a regional exchange, there seems to be less of a need to grant significant authority to regional regulatory institutions. For example, the Nordic Pool has been successful in creating an integrated regional power exchange through a decentralized framework. When Finland was looking to join Sweden and Norway in power trading, *Stattnet* (Norway) and *Svenska Kraftnät* (Sweden) required that the Finnish power sector should have the same structure as Norway and Sweden – by unbundling ownership of the grid and of production (Bredesen & Söderström, 2016). Hence, while Nordic countries have taken significant steps to harmonize regulatory frameworks to facilitate competitive power trading, each country has kept its legislative sovereignty; NordReg itself has a mandate to promote cooperation between national regulators, but has no legislative or executive power in the market (Pineau et al., 2004). This is also seen in the MER in Central America, where the CRIE does not need to have significant regulatory powers due to the high degree of institutional harmonization among domestic power sectors; instead, national regulators within the MER coordinate common market rules and implement MER codes, which determine the regulatory frameworks for national system operators concerning dispatch, tariffs and transmission services (Fedosova, 2015).

Within the European Union, there is also a relatively high degree of regulatory harmonization between countries participating within any of its sub-regional power markets – this limits the need for the respective sub-regional power exchanges to have substantial authority to intervene in domestic markets. However, the EU approach differs from other case studies in that while the authority for wholesale, retail and internal transactions remains with national regulatory agencies, European directives (transposed into national laws) ensure a minimum level of harmonization and consistency to promote cross-border trade in its sub-regional markets. EU Member states are required to conform to these EU legislations on electricity and gas markets, state aid, and competition (ESMAP, 2010c). To facilitate

this, the Agency for the Cooperation of Energy Regulators (ACER) was created in 2009 primarily to co-ordinate national regulatory agencies (Baritaud & Volk, 2014). For example, the First Energy Directive of the European Union in 1996 required open access to transmission lines, which is a pre-requisite to regional competitive electricity trading.

In addition, European institutions that have the authority to enforce competition policy and rule on disputes in the regional market exist, thus reducing the need for such functions to be duplicated within each European sub-regional electricity exchange (ESMAP, 2010c) – in 2009, the Swedish transmission system operator (a member of Nordic Pool) was subject to anti-trust action by the European Commission for shifting transmission constraints to international interconnectors to reduce constraints within Sweden. What this means is that, while there must be a minimum level of regulatory harmonization for the creation of a regional exchange, it is not necessary for the power exchange itself to wield authority over underlying domestic power sectors. Harmonization can also be achieved through consensus building among participating member countries, or through the imposition of certain market organization policies by regional entities that wield authority beyond the power sector, or beyond the sub-regional markets.

As a final note on regional regulatory structures, the ability for regional institutions to continuously adapt to local needs and changing circumstances is just as important as the original architecture of these institutions. In Europe, regional market institutions were granted more powers after a major shutdown of the synchronous system stemming from a disturbance in Italy in 2003, which led to the adoption of a multilateral agreement legally enforceable in the European Court of Justice. Special regional power cooperation arrangements were also made in Southern Africa's SAPP to ensure the security of power supply during the South Africa World Cup in 2010, against the backdrop of a serious lack of adequate reserves causing region-wide blackouts and load shedding. Furthermore, flexibility

is required because objectives (and hence, the focus) of power market integration may change over time (ESMAP, 2010c).

- Regional market operations

The regional transmission system operator (TSO) is crucial for the effective functioning of the regional power exchange, as it ensures that electricity flows efficiently through the regional grid from power generation plants to load centers. The role of the TSO is mainly to promote non-discriminatory access to transmission infrastructure, operate the system in real time, and manage transmission system congestion. Hence, the underlying principle that must be adhered to is that TSOs should be independent from the power market.

The case studies show that there are many different types of structures that can achieve this: the *Nord Pool Spot AS* was structured based on the principle that respective TSOs should be co-owners, which has been the working model for the expansion of the Nord Pool's membership (Bredesen, 2016). This is similar to the structure of North American ISO/RTOs, which are non-profit limited liability companies owned by member utilities. However, the American ISO/RTO model is unique among the case studies in that it is also able to achieve management independence – under FERC regulation, the respective ISO/RTO boards are made up of individuals that have no ongoing relationship with market participants (Oseni & Pollitt, 2014). It should be noted, though, that such independence is likely only possible within national boundaries – in transnational power exchanges, this structure is politically inexpedient as each country will have concerns about the impartiality of the regulatory/operator. The Southern Africa model of market operation stands out because it is not jointly owned by member utilities, even though there is equal representation in the SAPP Coordination Centre (SAPP's TSO that operates the DAM). Instead, members' contributions account for majority of its operating costs (ESMAP, 2009b).

- Regional power sector planning

Regional mechanisms for future infrastructure planning are not necessary pre-requisites for regional power exchanges to *function* – especially in regional markets that trade only excess power capacity. In the early stages of such market structures, the potential for opportunity trading exists primarily due to the lack of coordination between national power sector infrastructure plans, as well as mismatches between power supply and demand in real time.

However, regional power sector planning is important for two main reasons: First, the extent of efficiency benefits from trading on the regional power market– in the form of optimization of generation and transmission on a regional level – is partially determined by how member states coordinate such capacity expansions (ESMAP, 2010c). Second, as discussed earlier in this chapter, transmission and grid capacity is itself a key factor for regional electricity exchanges to *succeed*.

Pierce, Trebilcock, and Thomas (2007) identify that the coordination of transmission planning and investment is crucial for fully-integration regional markets to operate (Pierce, Trebilcock, & Thomas, 2007). The World Bank goes one step further, using regional power sector planning as a metric to determine the level of integration in the regional market – their study notes that **bilateral, cross-border power trading arrangements** tend to only require national-level planning and investment; **shallow market integration models** which function primarily based on long-term PPAs, supplemented by trading on short-term markets tend to require some level of power sector investment coordination through a regional plan; whereas **deep integration,** where a full competitive market offering a range of different market mechanisms is achieved, requires regional infrastructure investment plans to be implemented (ESMAP, 2010c).

All of the regional power exchanges studied in this thesis feature some form of regional coordination for power sector planning. In relatively developed electricity markets such as within the EU and North America, coordinated planning is mandated by bodies such as the European Commission and the FERC, respectively.

This has proven to be relatively successful in the EU – as of 2014, almost 60 interconnections under the EU's *Ten-Year Network Development Plan* were being developed (Baritaud & Volk, 2014).

However, while regional power sector planning may be mandated in some exchange areas, the actual *implementation* of these plans is a separate issue altogether. Within the US market, PJM's pricing models that form the basis for generation and transmission planning does not provide sufficient incentives for investments in congestion-reducing infrastructure (ESMAP, 2010c). This points to the fact that regional power sector plans can only come to fruition through creating the right market incentives. This problem was also seen in the SAPP, where the uncertainty of revenue flows associated with short-term trading may prevent investments in new infrastructure (Baritaud & Volk, 2014). The MER in Central America stands out as a (rare) positive example where regional transmission infrastructure was not only planned and implemented, but also formed the cornerstone of the regional market initiative. There are various contributing factors that can explain why the MER was successful in constructing the 1,800km, 300 MW SIEPAC transmission line: there was a high level of political commitment by member states to the project, evident from the signing of a *legally enforceable* treaty in 1996 which, among other provisions, called for the construction of the interconnection. In addition, the financing and market mechanisms ensured that the project was both economically and politically feasible – a Special Purpose Vehicle (SPV) was set up in the form of a joint venture between all six governments, thus ensuring that all concerned parties had a financial stake in the success of the project. Further, transmission pricing mechanisms were also decided beforehand to ensure cost recovery for the project (ESMAP, 2010a). Without agreed-upon cost allocation methodologies, Baritaud and Volk (2014) investment would be severely hindered.

6.1.3 Trading Arrangements of Regional Power Exchanges

The main advantage of a competitive power exchange is that it allows a higher level of price discovery – which then leads to the efficient allocation of

resources. In this way, the pricing mechanisms utilized by the regional power market is important. This section outlines the various spot, financial and transit pricing arrangements used by regional power exchanges around the world.

(a) Spot pricing mechanisms

Spot pricing leads to more competition (as compared to bilateral or multilateral trading arrangements), and hence, helps achieve greater efficiency in resource allocation (Oseni & Pollitt, 2014). Spot markets are especially important for the power sector – unlike other commodities, the storage of electricity remains prohibitively expensive, and generators have a limited speed at which they can ramp up and down (Schubert, Zhou, Grasso, & Niu, 2002). Due to these constraints, electricity must simultaneously be produced and consumed; hence, power production must be planned in advance, and the grid system also needs tools to make real-time adjustments in response to supply or demand shifts. Thus, spot market mechanisms such as day-ahead, intra-day, and real-time pricing are crucial for the power exchange to function efficiently. **Table 2** provides an example of the different types of spot pricing mechanisms currently utilized in some regional power exchanges:

Table 2: Spot Market Mechanisms utilized by Regional Power Exchanges

Regional Power Exchange	Physical Market Mechanisms		
	Day-ahead	**Intra-day**	**Real-time**
Nordic Pool	Yes	Yes	Yes
EPEX Spot (EU)	Yes	Yes	Yes
SAPP (Southern Africa)	Yes	Yes	No
MER (Central America)	Yes	No	Yes

NEM (Australia)	Yes	Yes	Yes
PJM (USA)	Yes	No	Yes

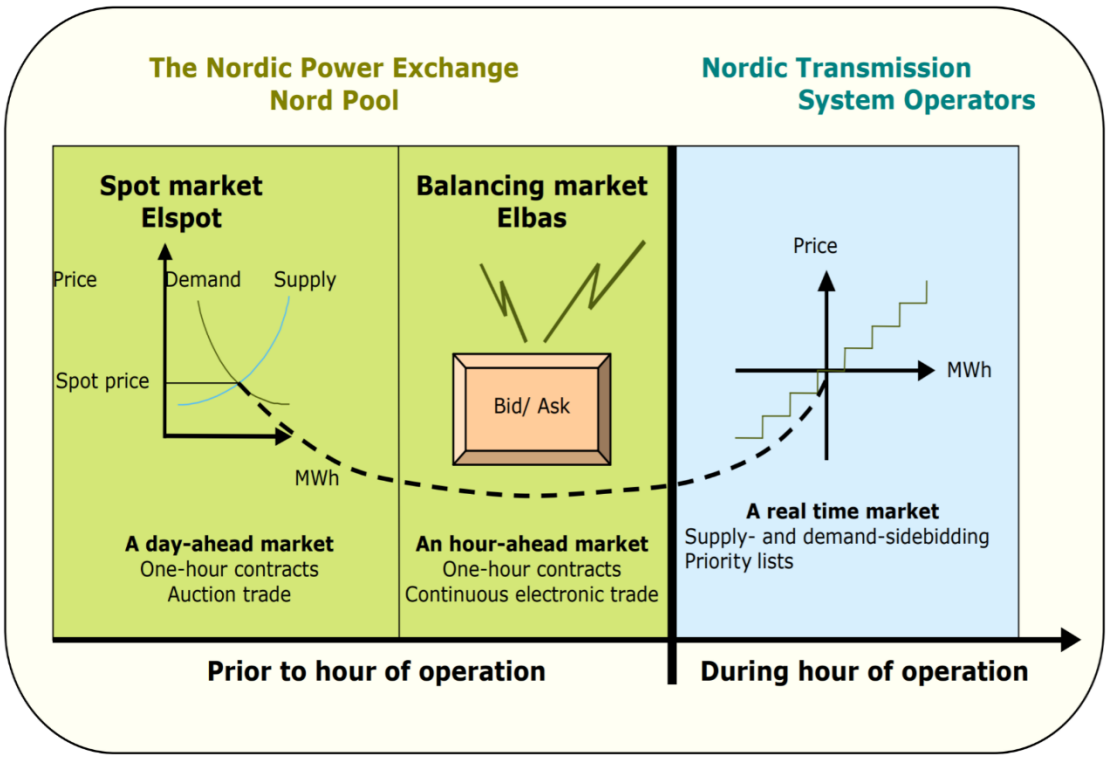
Source: Respective Power Exchanges

As shown above, all regional power exchange models have day-ahead market mechanisms to allow power producers to plan their dispatch in advance. In general, the more developed markets tend to utilize real-time market mechanisms, as this allows for a quicker response to supply or demand fluctuations. SAPP is also currently working on developing a real-time balancing market for this purpose (Beta, 2016).

Intra-day and real-time balancing markets are complementary to the functioning of day-ahead markets, as they allow power generators to make final adjustments to their dispatch portfolios, as well as manage incidents and failures in the power system between the closing of the DAM and delivery the next day (NordPool, 2004b).[7] How this works within the Nordic Pool is shown in **Fig. 10:**

Fig. 10: Nord Pool Spot Pricing Market Mechanisms

[7] For more information on how these market mechanisms function, see: *A Primer on Wholesale Market Design* (Schubert et al., 2002).



Source: Nord Pool, 2004

The main takeaway is that there should be some form market mechanisms to: (1) plan dispatch in advance; and (2) make final adjustments close to or in real time.

While having more market features is beneficial for market participants as it provides greater flexibility and stability, new power exchanges should be cautioned against launching too many trading products at once – especially if there are few market participants. This may lead to a dilution of trading volumes for each product, which prevents the market from gaining liquidity fast. Hence, this points to the need to roll out trading products gradually (this will be discussed further in **6.1.4**).

(b) Electricity derivatives market

The existence of market mechanisms for the trading of electricity derivatives tends to be indicative of more mature regional exchanges that are at later stages of development; these include the US domestic ISO/RTOs, the EPEX Spot, as well as the Nord Pool Spot. While the SAPP in Southern Africa offers monthly and weekly

forward physical contracts, it has yet to develop a market for financial trades (SAPP, 2015).

Market mechanisms that allow for financial trades are beneficial to market participants, as they provide hedges against electricity price volatility. This is especially important in markets with substantial intermittent power generation capacity (e.g., from wind or solar), as weather conditions can lead to unpredictability of dispatch for market participants; hence, in such markets, power generators can address the risks associated with weather-related uncertainty of dispatch through purchasing electricity derivative contracts (Baritaud & Volk, 2014). Financial markets are also important for the power exchange as a whole – the liquidity associated with increased trading volumes ensures greater price discovery.

As can be seen, derivatives markets can help enhance market stability and efficiency, but are *not* necessary for the regional power exchange to function. More information on the trading of electricity derivatives, as well as a discussion on several potential implementation issues, can be found in Baritaud and Volk (2014).

(c) Transit pricing

In any electricity grid (national or transnational), transmission charges ensure that the entities that own and operate transmission infrastructure are adequately compensated. In cross-border trading between two countries, trading arrangements are relatively simple, as the transmission lines utilized are usually owned by one or both countersigning party. However, transit pricing arrangements become much more complex when electricity trades are conducted multilaterally, regardless of whether these trades occur through a competitive regional exchange. In such situations, transmission lines owned and operated by a third party that is not the buyer or seller may be needed to deliver the traded volumes; hence, the third party must be adequately compensated. Transmission pricing is also crucial for the overall grid system, as it incentivizes investments into transmission infrastructure expansions, and ensures a high quality of operational service.

Some examples of transit pricing models utilized in regional electricity exchanges around the world are shown in **Table 3**:

Table 3: Examples of Transit Pricing Structures in Regional Power Systems

Regional Power Integration Initiative	Transit Pricing Arrangement
Southern African Power Pool (SAPP)	Nodal Pricing (MW-km model)
Nordic Power Pool	Nodal Pricing
Europe (various exchanges)	Zonal Pricing
Central America (MER)	Variable transmission charges[8]
U.S (PJM Regional Transmission Operator)	Locational marginal pricing and the longer-term Reliability Pricing Model

Source: WB ESMAP, 2010

Regardless, the main takeaway is not *which kind* of transit pricing model to use, but that there *is* a transit pricing mechanism in place to compensate transmission operators. For more information on the various transit pricing mechanisms, see: *Power Transmission and Pricing – Issues and International Experience* (Bodenhoefer & Wohlgemuth, 2001).

6.1.4 Approaches for Creating the Regional Power Exchange

Having explored the relevant features and structures required (or recommended) for the regional power exchange to function effectively, this sub-section delves into the various approaches that have proven to be effective for creating regional competitive power markets, based on international experience. Four main principles can be derived from the case study analysis: First, starting with a small number of participating countries is an effective approach to market development. Second, both policy-led and market-led approaches to creating the regional market can be successful, depending on the regional context. Third, the sequencing of steps can also affect regional market development, as will be

[8] Central America's variable transmission charges are currently being phased out in favor of nodal pricing (ESMAP, 2010a). For more information on its variable transmission pricing model, see: *The Regional Electricity Market of Central America* (Prada et al., 2004).

discussed. Fourth, institutional partners have played important roles in the creation of regional power markets, both in terms of financing as well as institutional development.

(a) Start small

International experience has shown that starting from, just two or three market participants, has been a successful model for creating a regional market. Oseni and Pollitt (2014) propose that this allows the benefits of trade to be demonstrated, showing new parties that they would be joining an existing arrangement that works. Several functioning regional power exchanges have developed in this way – PJM began with just three utilities in 1927, gradually expanding in terms of scope, members, and coverage over time. The EU has also utilized this model for its market integration project, by adopting a "sub-regional markets" approach – the development of four regional markets are seen as stepping stones to creating an EU-wide power market (Egenhofer & Genoese, 2016). In contrast, the WAPP's slow development can be attributed to the large number of participating countries right from its inception, rather than adopting an organic growth approach (Oseni & Pollitt, 2014).

The Nordic experience has been unique in that growth of the regional market was achieved through the inclusion of cross-border participants in Norway's domestic power market. The Nord Pool was established in 1993, and functioned as a competitive market that operated only in Norway. In 1996, Sweden began to participate in the Nord Pool Exchange after reforming its domestic power sector. Subsequently, more regional players were gradually added to the power pool, with the market eventually encompassing trade between nine countries (Carlsson, 1999; Flatabo, Doorman, Grande, Randen, & Wangensteen, 2003; Oseni & Pollitt, 2014).

(b) Policy-led approach vs. Market-led approach

A policy-led approach creating a regional electricity exchange is based on top-down, regional regulation and enforceable directives; in contrast, a market-led

approach is driven by organic growth, with market players participating in the competitive regional market based on economic incentives.

Policy-led approaches to creating regional power exchanges can be effective, as regional directives help to codify the political will for competitive power trading into a binding commitment with actionable steps; such as a treaty or protocol that is legally enforceable (Castalia, 2009). This was seen in the European Union's regional exchanges, where cross-border market integration has largely been driven by EU legislators and regulators through its regional energy directives (Pineau et al., 2004). Central America's MER also benefitted from the legally-binding Framework Treaty, which entered into force in 1998; the Treaty introduced an enforceable mechanism for the six participating countries to implement the market.

The efficacy of the policy-led approach has been the basis for Castalia's (2009) recommendations to the SAPP to adopt protocols along the lines of the MER, arguing that it would lead to greater regulatory certainty for power trading. The World Bank ESMAP (2010) supports this view from another angle, stating that the formal endorsement or signing of regional power investment plans by Heads of State creates visibility of the political buy-in, which increases the chances of success.

However, the policy-led approach may not always be the politically-expedient option, because it requires a significant shift away from a consensus-based and voluntary approach to market development. In agreeing to be bound by such legally-enforceable regional frameworks, national governments effectively cede some level of sovereignty. As an alternative, a **market-led approach** has proven to be equally successful, as seen in the Nordic power pool. As mentioned earlier in this chapter, the Nord Pool market grew organically, driven by market players' overwhelming incentives to participate in the regional market; hence, there was little need for any regional-level policy mandates.

In reality, the need for top-down policies and directives is highly dependent on the nature of underlying domestic power sectors within the regional market –

where market players themselves are able to (or have sufficient incentives to) harmonize domestic regulations and processes to facilitate trade, there is less of a need to adopt a policy-led approach.

(c) Sequencing of steps

This sub-section discusses the approach to market implementation based on a variety of chronology-based perspectives: should physical infrastructure be developed before regional market institutions? Should the regional market start from trading of surplus, or begin directly with a fully-integrated market? How should different market mechanisms be introduced?

- Physical Infrastructure development vs. Institutional development

A comparative analysis of the different regional power exchanges around the globe indicates that a minimum level of physical infrastructure is required for competitive power trading to occur. Western Africa's experience with regional power markets shows that physical infrastructure can be a stumbling block for the market to begin operations – the WAPP's inability to evolve beyond bilateral trading is primarily due to a lack of transmission capacity (Oseni & Pollitt, 2014), as this creates a bottleneck in power flows (Baritaud & Volk, 2014).

However, once this minimum level is met, the exchange can begin operation, albeit with a limited number of players. This is also in line with the principle of starting small previously discussed – the market can (and should) expand as physical transmission lines are gradually developed to include more countries. Starting small could be a more manageable approach, in comparison to struggling to create an extensive regional physical grid infrastructure incorporating many players right from the start.

In fact, even for regional power markets that are mature, transmission capacity should continue to be developed to match electricity demand growth and increasing trade flows. Hence, once cross-border transmission capacity is enough to

facilitate competitive power trading, both physical as well as institutional infrastructure should be developed concurrently. Where physical infrastructure does not increase apace with market growth, it can become a limiting factor for the deepening of regional power sector integration in the later stages. Considering the case studies of both the MER and the SAPP, Oseni and Pollitt (2014) conclude that while limited cross-border transmission capacity has not prevented the emergence of spot markets, it has severely limited their significance, thus explaining the prolonged dominance of bilateral trading.

The MER is an exceptional case study in that market institutions were created before the development of physical infrastructure for trade – the six Central American countries deliberately developed *Mercado Eléctrico Regional* (MER) before building the SIEPAC regional transmission line to make trade physically possible (ESMAP, 2010c). This proves that institutional structures can be developed first – however, the fact remains that a minimum level of *both* institutional and physical infrastructure is required for the competitive market to function.

- Trading of surplus capacity vs. Full integration

A feasible approach is for regional electricity exchanges to start from the trade of surplus electricity, before gradually evolving into a full electricity market – this is borne out in the experience of the Nordic power pool, as well as the SAPP and (potentially) WAPP. The Nord Pool market began in the 1960s based on the principle that each participating country would have enough power generation capacity to ensure self-sufficiency; hence, trade was only conducted to achieve optimal dispatch – whenever there was a difference in the marginal cost of production between participating countries, trading occurred. Due to surplus hydropower generation capacity in Norway, this model then evolved into a fully integrated power exchange in the 1990s. The SAPP also adopted this approach, by beginning with the trading of uncommitted surplus energy (Carlsson, 1999). The WAPP is also likely to create an electricity market based on the allocation of excess production among participating

countries (Oseni & Pollitt, 2014). It should come as no surprise that the SAPP and WAPP have taken a similar approach to the Nordic Pool, as both were adapted from the Nordic model.

- Introduction of market mechanisms

International experience reinforces the idea that market mechanisms should be introduced gradually. Spot markets are crucial to allow physical power flows to occur within a competitive regional market framework, and hence, should be developed first. As mentioned earlier in this chapter, financial markets are helpful but not strictly necessary; these can – and often are – introduced at later stages of market development. This sequencing has worked in Southern Africa – the DAM began operating in 2009, and the SAPP is currently working on the creation of a market for the trading of electricity derivatives (Beta, 2016).

Within spot and financial markets, market mechanisms have also evolved over time in developed power exchanges, with new product offerings being introduced gradually. For example, PJM began as a power pool in 1927, but its capacity markets only start operating in 1999. Annual Financial Transmission Rights (FTRs) auctions began in 2003, and the Day-Ahead Scheduling Reserve market was introduced in 2008 (ESMAP, 2009a). Within the EPEX Spot region, gradual market evolution is also seen from the fact that its intra-day binding traditionally operated based on lead times of one hour before delivery; before being reduced to 30 minutes before delivery in 2015. In addition, EPEX Spot has introduced new market features into its underlying markets at different times – in 2011, 15-minute contracts were launched in the German intra-day market, before being rolled out in Austria in 2015 (EPEX, 2017).

(d) Role of institutional partners

Partnerships with multilateral development institutions have been helpful for the development of both physical infrastructure as well as regional market institutions. First, international development agencies can (and often do) help to

meet the financing gap for regional power sector integration, which is especially significant due to the high capital costs. Oseni and Pollitt (2014) state that all the regional power initiatives in their study (ie. SAPP, WAPP, SIEPAC, PJM, and two European sub-regional grids) have been financed by international development agencies. Within Central America, the Inter-American Bank provided 59.3% of the initial funding for SIEPAC transmission line, which amounts to $240 million of loans (ESMAP, 2010a). Even within Southeast Asia, both the Asian Development Bank (ADB) and the World Bank have been key partners for the Global Mekong Sub-region (GMS) power connectivity project right from its inception, sponsoring or co-financing many of the planned interconnections and power generation projects (ESMAP, 2010b). The involvement of international development institutions may also have a halo effect on these large transmission infrastructure projects, making these projects more attractive to private sector investors.

Second, in addition to financing, international development institutions also provide valuable expertise, and have been vital in the institutional growth of some regional initiatives. This has been seen from the technical assistance and advisory support that institutions such as the World Bank, USAID, and the IEA continue to provide to various power sector integration projects in developing regions; such as Sub-Saharan Africa and Southeast Asia. Within the GMS, the ADB is the acting secretariat for the power connectivity initiative, coordinating its activities while also providing technical and logistical support to GMS institutions (ESMAP, 2010b).

6.2 What do these findings mean for the AEE?

The previous sections of this chapter have identified certain pre-requisites for the creation of a regional power exchange, as well as the structures, features, and approaches that have worked, based on the experience of other regions. This has confirmed the underlying hypothesis of this thesis – that there is no one model for regional electricity market integration. Each regional market integration initiative must adapt its institutions and approaches to its own regional context and constraints. In adherence to this principle, this section discusses the research findings

within a Southeast Asian regional context, in order to propose certain lessons for the AEE. These include the approaches to implementing the AEE, as well as suggested elements for the market model – such as recommended market mechanisms and regional institutions.

- The ASEAN Power Grid initiative has certain advantages over other regional markets

Before discussing lessons for the AEE, it is good to first recognize the advantages enjoyed by the APG initiative, which can help facilitate the creation of a competitive regional market: First, Southeast Asia exhibits strong power sector resource complementarity, primarily due to the fact that these electricity resources are unevenly distributed across the region (see: **Chapter 2**). This provides a strong impetus for power trading, thus increasing the political will among ASEAN governments. Resource complementarity has been an important contributing factor to the success of other regional power sector projects, such as the SAPP and Nordic pool (Pineau et al., 2004).

Second, ASEAN has strong partnerships with international institutions, which include donor support and technical assistance. Apart from the World Bank and ADB's contributions to power connectivity within the GMS; the AEE initiative has also begun to involve the *United Nations Economic and Social Commission for Asia Pacific* (UNESCAP) and consultants from the Nordic Pool – in fact, the most recent AEMI workshop on the AEE was jointly organized with UNESCAP, which representatives from the IEA and the World Bank in attendance.

Third, ASEAN has already adopted a gradual approach to the creation of a regional power grid – similar to the EU's implementation process, the APG is also looking to build the regional market through developing various sub-regional projects. However, while countries in the Northern and Southern subsystems[9] are

[9] The Northern Subregional system includes Viet Nam, Lao PDR, Myanmar and Thailand; while the Southern subregion of the APG encompasses Malaysia, Singapore, and Sumatra in Indonesia (IEA, 2015a).

looking to implement mechanisms for multilateral power trading, there has been little institutional development in the Eastern subsystem (encompassing Brunei, Indonesia, and the Philippines). Furthermore, the LTM-PIP is another example of how ASEAN is looking to develop multilateral trading mechanisms within a few member countries first (in this case, Laos, Thailand, and Malaysia), before utilizing these mechanisms in other sub-regions.

Fourth, the APG has demonstrated flexibility in evolving its goals and approaches in implementing a regional power market. ASEAN seems to pursue power sector integration by simultaneously utilizing multiple frameworks. While there has been little synergy between these separate frameworks, this approach has successfully facilitated the development of ASEAN's physical and institutional power sector infrastructure.

Within Southeast Asia, the GMS power connectivity project evolved under institutions separate from the APG framework. Initially, the APG did not share the GMS' vision of creating a competitive electricity market; however, there has recently been a convergence of goals – the GMS was subsumed under the APG framework as its Northern sub-regional grid (although there has yet to be evidence of significant collaboration between APG and GMS institutions). In addition, with the recent AEE initiative, the APG has also begun to seriously consider the implementation of a platform for competitive power trading.

- Pre-requisites for the creation of a regional competitive market

A comparative analysis of regional power sector integration projects around the world proves definitively that significant **domestic electricity market restructuring** – such as vertical unbundling and privatization of national utilities – is *not* a pre-requisite for regional power exchanges to function. This is true regardless of whether the exchange trades only excess production, or is a fully-integrated market. This is an important insight for the AEE, given that most Southeast Asian power market structures are still based on enhanced single buyer models, featuring

vertically-integrated state-owned power utilities. Hence, the AEE will likely not have to deal with political feasibility issues related to vertical unbundling – at least in its early stages.

However, the **removal of producer-side subsidies** *is* a pre-requisite for the creation of a competitive regional market, as these subsidies may prevent cross-border electricity trades from being commercially viable. While ASEAN governments have taken considerable steps to achieve this, it remains to be seen if such reforms will be politically feasible. In addition, **open access to transmission infrastructure** is also another pre-requisite. However, the AEE's current model of the trading of surplus electricity may only require that TPA is implemented for the uncommitted capacity of ASEAN's transmission infrastructure. In this way, the financing arrangements of transmission infrastructure will not be affected, which is a significant economic consideration given the high capital costs. TPA to transmission infrastructure will ultimately be required in the later stages, for the AEE to see deeper market integration. There are two potential pathways to achieving this without affecting the project finance structures of power transmission projects – TPA can be instituted as the long-term PPAs of each transmission line expire (and the costs are fully recovered); or, if profits from trading on the AEE prove to be significant, it could also lead to a re-structuring of these long-term, bilateral agreements to allow for more capacity to be dedicated to open access competitive trading. Of course, governments can also step in and mandate open access to transmission infrastructure; however, the financial arrangements will still have to be viable if governments do not plan on picking up the tab. The fact that state-linked companies dominate the power sector in most Southeast Asian countries could be a potential opportunity – as long as there is sufficient political will, governments have more control over these companies to institute TPA provisions in existing contracts.

- How does ASEAN's consensus-based and voluntary approach impact the AEE?

Having identified the pre-requisites for power trading, it is important to point out that there are multiple pathways to achieving them. However, ASEAN's emphasis on voluntary participation and consensus-based decision-making in energy cooperation sets the parameters for the AEE's possible approaches to market development. Southeast Asian countries' strong views in favor of maintaining sovereignty over domestic affairs essentially rules out the possibility of creating a supranational authority to implement the regional power exchange through regulations and policy mandates. Contrary to the World Bank's proposals for the GMS power connectivity initiative (ESMAP, 2010b), the primacy of sovereignty concerns limits the probability that ASEAN member states will enter into legally-binding arrangements to achieve regional electricity market integration. Hence, a market-driven approach to power sector integration, based on harmonization between market participants wherever there are incentives to do so, seems more feasible in ASEAN than a policy-driven approach. This is similar to the "ASEAN – X" approach that ASEAN has adopted to move forward in other areas where not all of ASEAN's ten member-states are ready.

This thesis discusses two potential options to create a regional power exchange without a supranational authority, and without the need for regional institutions with regulatory and enforcement powers. These options are based on the Central American MER and the Nord Pool models, respectively. Out of the regional power markets covered in this study, these two models stood out as they maintained the sovereignty of national power market regulation. While the EU's push for a regional electricity market has been relatively successful, it is fundamentally based on the fact that all the European Commission's has significant supranational authority – its legislations must be adopted by EU member states. Similarly, North American ISO/RTOs have been relatively successful, but this has also been based on the wide-reaching legislative and executive powers granted to national energy sector regulatory institutions, such as the FERC and the NERC.

The SAPP and WAPP regional electricity markets in Africa have been based on voluntary trading, with limited supranational authority granted to the respective regional regulatory bodies. However, since they were adopted largely based off the Nord Pool model approach, it may be more efficient to focus on the Nord Pool, which is much more mature.

The **Nord Pool approach** is based on starting with a single country that already has a functioning, competitive domestic electricity market, and gradually expanding the market to include market participants across borders. This could be a double-edged sword for the AEE initiative – on the one hand, the prospects of participating in the market could incentivize domestic regulatory harmonization across country borders, as was the case in the Nordic Pool. Conversely, it could also delay regional market development if participating countries are unwilling to engage in these reforms. Much of this depends on the political will of participating countries in the regional power initiative.

If this approach were to be adopted in Southeast Asia, it would likely involve the domestic competitive exchange of Singapore or the Philippines, as both countries have relatively mature national electricity markets (compared to other ASEAN nations). However, there is currently no cross-border power interconnection between the Philippines and any other ASEAN country; the Philippines-Sabah transmission line is planned for completion only in 2020 (APPP, 2015; ASEAN, 2009). The case of Singapore is also distinct from the Norwegian experience – Norway's drive to extend its domestic market to Sweden was largely based on an oversupply of hydropower capacity; in contrast, Singapore's higher marginal cost of power production means that it is currently not economically viable for neighboring countries to purchase electricity from the Singaporean domestic market. However, given grid stability issues currently plaguing Sumatra, Sumatra could also choose to buy more expensive power from Singapore to buffer vital industries from the effects of seasonal or daily shortages, through competitive trading. Conversely, Singapore has high power sector reserve margins; which explains why it removed itself from

the original LTMS-PIP initiative. Hence, Singapore does not *need* to include foreign power generators on its domestic exchange in search of electricity imports, but may consider doing so for cost-efficiency reasons or to reduce carbon emissions. More studies will need to be done to analyze economic feasibility based on potential electricity surpluses or deficits in both the Filipino and Singaporean national power markets.

The second approach is inspired by the **MER model** of Central America, where the regional electricity market superimposes over the underlying domestic markets. While this may require regional institutions to have some level of authority to regulate and operate the regional market, there should not be any intervention required in the various national power sectors. The main difference between the MER and the AEE in its current form is that the SIEPAC transmission line, which spans all six Central American countries, was constructed with the express purpose of facilitating competitive power trading in the MER; in contrast, the AEE is based on the trading of surplus electricity using the current patchwork of cross-border transmission capacity within the APG. Hence, this idea of a regional market that functions above and separate from underlying domestic markets will need to be implemented on a sub-regional basis within ASEAN. These markets will then have to be coordinated such that they can eventually be unified when the underlying physical infrastructure allows for it.

It is important to once again reiterate that the complete adoption of a single model will not work in Southeast Asia's unique context. Hence, elements from either (or both) models should be incorporated into the AEE. Table 4 summarizes the advantages and disadvantages of both approaches, based on a preliminary study:

Table 4: Evaluation of MER and Nord Pool Approaches to Regional Power Markets

Mercado Regional de Electridad (MER) Approach	Nordic Pool Approach
Advantages: Top-down approach creates a regional market involving all participating countries in Central America. Regional market that superimposes over six participating countries allows domestic markets to develop at their own pace.	**Advantages:** Organic approach to market development does not require that extensive authority to intervene in domestic markets are granted to a regional institution. While foreign entities must abide by the market rules set out in the host country, it does not require electricity market reform in their home markets.
Disadvantages: Requires a high level of political commitment (ie. Signing of a treaty), short of granting supranational authority to the regional market institution.	**Disadvantages:** Requires the existence of a relatively liberalized domestic power market in which other foreign electricity market players can participate in.
Comments: One of the key ways in which the MER circumvents the problem of TPA is through financing a new SIEPAC transmission line that cuts across all participating member states. This is unlikely to happen in Southeast Asia.	Comments: The Nord Pool model began because their was an economic incentive for Norway to look for export markets for their surplus hydropower capacity. Likewise, cross-border trading in Southeast Asia needs to develop based on market incentives.

Much more research should be done to determine the economic viability (and relative efficacy) of both these approaches for the ASEAN Electricity Exchange. In addition, market development in the MER should continue to be watched, as the market is not yet operational (pending the completion of the SIEPAC line).

- Regional institutions

As mentioned, a supranational authority that has the power to intervene in the domestic power sectors of ASEAN member states is not likely to be politically expedient. The experiences of other regional power market initiatives suggest that where regional institutions have little or no power to intervene in national markets, harmonization between the various power sectors must be achieved on a voluntary basis. Against this backdrop, regional transmission operators and regional regulatory institutions are crucial to serve as a platform for coordination between the various national institutions. When such institutions function on a regional level, it is less likely that they can be completely unbiased and independent from market operations. Hence, equal representation seems to be a more workable model to ensure that participating countries have adequate trust in regional institutions.

As seen from the case of the GMS power connectivity initiative, conflicts can arise over the location of these regional institutions. Southern Africa successfully tackled this problem by having the host country, Zimbabwe, pay an additional 10% contribution to the regional market operator's annual budget, as a compensation for the potential advantages that may arise from locating the institution in Zimbabwe (ESMAP, 2009b). A similar solution could work within an Southeast Asian context. Nonetheless, the creation of ASEAN itself as a regional institution should give some cause for optimism, as the five founding members of ASEAN were ultimately able to reach a consensus on situating ASEAN's headquarters in Jakarta.

In terms of regional institutions for power sector planning, ASEAN already has a substantive regional infrastructure plan, as seen in the APAEC. However, just like in other regions, the implementation of these plans is ultimately dependent on private sector considerations. Here, Southeast Asian governments, together with ASEAN as a regional institution, can do much more to increase the attractiveness of these infrastructure projects to private sector investors. This can be achieved in a variety of ways, such as through improving the domestic business environment by

increasing the strength of regulatory frameworks, and providing targeted concessionary financing to improve to the economic feasibility of crucial transmission infrastructure.

- Recommended market features

International experience has shown that spot markets for physical power trading should be developed before financial markets – the latter can help bring stability and flexibility to participants in the power exchange, as well as improve price discovery, but is not strictly required. With regards to spot market trading, the findings of this thesis support the outline of the AEE's feasibility study, which identified the DAM and settlement mechanisms as crucial components of the competitive regional market. The main lesson for the AEE is not what specific features for the DAM and intra-day markets are utilized, but that they exist. Of course, a deeper analysis should be done to determine which specific DAM and intra-day product offerings should be featured in the market, but this discussion lies outside of the thesis scope.

In addition, transit pricing is crucial for the creation of a regional power market – competitive or otherwise. Based on the APAEC 2016 – 2025 blueprint targets, as well as the project timeline of the LTM-PIP initiative, the mechanisms for transmission pricing are expected to be operational by 2018.

Chapter 7: Conclusion

Given that the ASEAN Electricity Exchange is a relatively new concept within the ASEAN Power Grid framework, this thesis set out to: (1) place the AEE initiative within the context of the APG by discussing how it could work as an alternative and effective approach to regional power sector integration; as well as (2) propose recommendations for the APGCC to implement the AEE by critically analyzing the lessons from other regional power exchange initiatives based on the Southeast Asian regional context.

The first half of this thesis (Chapters 1 – 3) explains the raison d'être for the AEE initiative, by discussing the current challenges facing the APG project, and the inadequacy of some of the traditional solutions suggested in the academic literature. The experiences of other regional electricity market initiatives around the world (discussed in Chapter 6) tend to reinforce the proposed regional-level solutions, which include:

- Partnerships with multilateral institutions to address the APG's financing deficit
- The need for cost-allocation methodologies to incentivize private sector investment into the required transmission infrastructure
- Harmonization of legal and regulatory frameworks to facilitate regional power trading

Even so, national concerns over energy security, the difficulties in allocating the APG's costs and benefits; and the lack of mutual trust have so far impeded the ability of ASEAN governments to cooperate on creating fully-integrated regional power market, and will likely continue to do so.

In addition, the various national-level "solutions" recommended tend to be even less feasible, due to Southeast Asia's socio-political realities. First, domestic market reforms – which include market liberalization, privatization and ownership

unbundling of national utilities – tends to be politically inexpedient due to vested political interests, nationalistic tendencies and the strength of domestic labor unions. Second, the complete removal of end-user subsidies tends to be extremely unpopular, and hence, difficult for politicians to initiate. Third, the creation of an independent domestic market regulator is important to prevent market distortions in the regional market. However, this is also relatively infeasible in some ASEAN countries due to strong political links between the government and the electricity sector.

Within the context of these regional constraints, **Chapter 4** explains how the AEE is a potential compromise solution for the APG. The creation of a regional market that trades only surplus capacity allows for opportunity trading between participating countries without the need for extensive reforms in the domestic power sector. Hence, this thesis proposes that the AEE (as proposed by HAPUA/AEMI) could be an important interim step for the creation of a fully-integrated and competitive regional market, while also allowing ASEAN member countries to reap some of the benefits from regional power sector integration. This approach can also be adopted concurrently with the APG's other initiatives, such as physical infrastructure expansion, as well as the realization of multilateral electricity trading between Laos, Thailand, and Malaysia.

Having established that the AEE can potentially be an effective approach that contributes to the APG's vision, **the second half** of the thesis then proposes specific design features for the AEE, as well as implementation approaches. These recommendations are based on the lessons from other regional power sector integration projects. While these findings alone are not new, the value-added from this thesis is that it summarizes these research findings, and adapts them for implementation within the Southeast Asian regional context. The recommendations are discussed in the next section:

7.1 Summary of Research Findings – Recommendations for ASEAN

The main lessons that were identified for the design and implementation of the ASEAN Electricity Exchange are:

- **ASEAN should focus on soft infrastructure development for regional power trading**

When compared to some other developing regions, Southeast Asia has made significant progress in constructing physical cross-border transmission infrastructure; hence, ASEAN should focus more on the development of the soft infrastructure required for competitive regional power exchange, such as regulatory harmonization and creating mechanisms for power trading.

- **The trading of surplus electricity generation capacity on the AEE does *not* require significant restructuring of domestic electricity markets**

The creation of some other competitive regional power markets in the world was achieved without the privatization and ownership unbundling of national utilities. Hence, while such domestic market reforms are beneficial to the efficiency of the domestic power sector, and would help to deepen regional power market integration at the later stages of market development, these steps are *not* pre-requisites for creation of the AEE.

- **Third-party access to transmission infrastructure is a fundamental pre-requisite for the creation of a regional electricity market**

Based on the AEE's model of trading only surplus generation capacity, third-party access need only be instituted for the uncommitted capacity of power transmission infrastructure in Southeast Asia. This is a much more feasible approach than attempting to institute complete open access across the region – the latter would likely have significant negative implications for the finances of existing transmission lines, and would also reduce the level of investment for

new projects. However, TPA would be eventually become crucial for the deepening of power sector integration in the later stages of market development.

- **The removal of producer-side subsidies is crucial to prevent distortions in the regional market**

While domestic consumer-side subsidies have a limited impact on price discovery and market efficiency in the regional competitive power exchange, producer-side subsidies in ASEAN's domestic power sectors *must* be phased out – by making electricity imports uncompetitive with potentially less efficient domestic production, such subsidies pose a significant barrier to the realization of cross-border trade opportunities. This is because subsidies to domestic power generation companies give them a significant advantage over electricity imports – even if domestic production is less economically efficient.

- **There are two potential market structures that may be relevant for the AEE's implementation**

This thesis assesses that two potential market structures are best suited to ASEAN's own regional context and constraints – Southeast Asia's regional market can superimpose over the various national power sectors (as in Central America's MER experience); or, it can be created by expanding one or both of ASEAN's two competitive domestic markets (in Singapore and the Philippines) to include participants from neighboring countries, wherever cross-border transmission lines exist to facilitate transnational electricity flows (as in the Nord Pool experience). As mentioned, the feasibility of both these options should be explored in greater detail through further analysis.

- **Granting regional institutions an ASEAN supranational authority is politically inexpedient but also unnecessary for AEE's implementation**

ASEAN's regional institutions have always functioned based on the principles of regional consensus and non-intervention in domestic affairs. Hence,

it is infeasible to expect national governments to cede significant authority to a supranational regional body, which can intervene in the various domestic power sectors. International experience shows that such an authority is not necessary for the creation of a regional exchange. However, in its absence, participating countries within Southeast Asia will have to find other ways to achieve regulatory harmonization to facilitate power trading.

The structure and authority of regional institutions required for the AEE also depends on numerous other factors, such as the potential market structure selected (as discussed in the previous sub-section). The main finding here is that these institutions should be structured in a way that ensures equal representation among ASEAN governments.

The GMS currently experiences certain challenges with regards to achieving consensus on the location of its regional institution. Here, the SAPP experience could prove to be instructive – participating member countries were able to reach an agreement by having Zimbabwe, the host country, make an additional contribution to regional market operations to compensate for any potential advantages.

- **Market mechanisms should be introduced gradually for the AEE to succeed**

  There *must* be some form of spot market mechanisms to allow for price discovery within the AEE. Based on the experience of other regions, this has often been institutionalized through day-ahead markets, with some market mechanisms to facilitate intra-day market balancing. Other types of spot pricing mechanisms can be gradually introduced as the market matures. In contrast, financial markets are beneficial but *not* necessary for competitive regional power trading to occur. Hence, platforms for the trading of financial derivatives can be introduced later.

7.2 Thesis Limitations

This M.A. thesis was intended as a holistic study on the ASEAN Electricity Exchange initiative; hence, it deliberately prioritizes breadth over depth, to provide broad-based lessons for the APG project. A broad range of issues concerning the development of regional electricity exchanges are covered, cutting across multiple countries and jurisdictions. However, it is important to also recognize that each individual issue and region could have been explored as an entire thesis in its own right.

Due to resource (and time) constraints, this thesis also utilized secondary sources for its analysis. While other academic scholars, as well as renowned institutions such as USAID and the World Bank Group have extensive resources and expertise to bring to bear in their analyses, having direct access to primary sources such as ASEAN energy policymakers or power sector industry players would have brought a much more nuanced and in-depth perspective to this thesis.

Further, while this thesis proposes recommendations for the AEE initiative, it does so from a regional perspective, given Southeast Asia's regional context. It would be interesting – and no doubt informative – to identify recommendations for each individual ASEAN country, based on considerations of politics, economics, energy resources, and society on a national level.

7.3 Potential Areas of Further Research

Apart from these limitations, there are also certain aspects of the ASEAN Power Grid initiative that were glossed over in this thesis, but are worth delving into further. First, enhancing the deployment of renewable energy sources has been identified as one of the key goals of the AEE (see: **Chapter 4**). While the thesis does explain the climate change benefits of the APG in **Chapter 2**, further analysis should be conducted to identify mechanisms for the AEE to incorporate market mechanisms that incentivize the deployment of renewable power.

Second, while the AEE initiative will increase aggregate economic welfare across the region, both **chapters 2** and **4** raise the issue that some groups will no doubt be adversely affected by the competitive regional power trading. Hence, further research should be done to identify the communities or industries at risk, in order for policymakers to ensure that they do not fall through the gaps.

Third, distributed power generation – especially from residential solar technologies – is currently on the rise in Southeast Asia. However, there is a currently a lack of understanding of how distributed generation may impact regional power sector integration in ASEAN; thus, further research should explore this topic in greater depth.

Finally, this thesis provides some recommendations for the creation of a regional ASEAN market that facilitates the competitive trading of surplus generation capacity. The next stage could involve scenario planning, to identify the key drivers and alternative pathways that could help the APG achieve a fully-integrated regional power market.

7.4 Final Note

As a final note, this thesis does not claim to be an authority on either regional power sector integration, or Southeast Asian power markets. It can only hope to make a small contribution to the APG initiative, by adding substance to the AEE's ongoing feasibility study process, and proposing new

ideas for the implementation of a regional electricity market. Given the potential impact that the APG project could have on ASEAN economies as a whole, as well as on millions of lives across the region, one can only hope that the APG will be a resounding success, and a future regional power sector integration model for other regions to replicate.

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APPENDIX

Appendix A: Literature Review

1. Overview of Academic Literature

Oseni and Pollitt (2014) analyze wide area electricity trading from the perspective of institutional arrangements that facilitate such trade. First, the paper engages in a theoretical study of power sector trade, based on the existing literature. This theory is then put into a real-world context, through an analysis of the institutions that underpinned the development of power pools in two groups of case studies: developing countries (SAPP, WAPP, and SIEPAC), and developed countries (PJM, SEM, ECSEE). Based on these experiences, the authors conclude with lessons for regional integration in South Asia: Sufficient political commitment to free trade, as well as the availability of transmission capacity are pre-requisites for electricity market integration. Strong, efficient and independent institutions are also necessary for the integrated power market to function effectively. A cross-border regulatory authority is not a pre-condition for the creation of a regional market, but external regulatory oversight is beneficial to reduce market distortions. Conversely, a well-designed market reduces the need for cross-border regulation and enforcement. In this regard, day-ahead and real-time markets have proven to facilitate greater market efficiency. The paper also proposes that power pools should start with fewer members, and grow gradually over time.

Fedosova (2015) analyzes the Nord Pool, MERCOSUR, EPEX Spot, MER, and NAFTA power trading systems in order to identify the factors that affect the power market integration process. The case studies were selected to incorporate a diverse range of experiences from different continents, featuring regions at different levels of market integration. The research includes the most recent available trade statistics, information about planned investment projects, as well as market organizational structures. The analytical framework used to assess power sector integration across the case studies looked at infrastructural, regulatory, and commercial indicators of integration. The paper concludes with a list of positive and negative factors of electricity market integration. The positive factors include complementary generation systems, the existence of market mechanisms for allocating and pricing transmission capacity, and regional regulation. The negative factors include

undeveloped domestic power sectors, unclear national market regulation rules, as well as differences in the level of privatization and liberalization of the respective domestic sectors.

Baritaud and Volk (2014) analyze the integration of electricity markets on three levels – policy, regulation, and commercial market integration. The report, published by the IEA, considers the case studies of power markets in North America, Europe, and Australia, in order to identify barriers to and best practices of market integration. The report proposes two separate paths to market integration – market consolidation and market coordination. It concludes that there is a need for policy commitment in order to see through the development of a wide area power network. Given that electricity security is a priority for governments, regulators and system operators, the regional regulatory framework should thus be harmonized with the view of achieving this. In addition, physical interconnectors form "the backbone of electricity market integration." To finance new connections, the authors propose that methods of cost allocation reflect the benefits from this infrastructure. Furthermore, they emphasize the role of governments and regulators in establishing sound policies, regulatory frameworks, and institutions that can facilitate market integration.

The **IEA's 2016** publication, *Large-Scale Electricity Interconnection: Technology and prospects for cross-regional networks*, compares three case studies (Europe, SIEPAC, ASEAN) based on their current state of physical and market integration. It concludes by proposing market and regulatory frameworks that could facilitate efficient investments in and the utilization of power interconnections in the future. These recommendations include the use of the "beneficiary pays" principle of cost allocation for financing new transmission infrastructure, as well as market frameworks to allocate transmission capacity.

Pierce, Trebilcock, and Thomas (2007) identify five characteristics of a fully integrated regional electricity market, and discuss the potential barriers to achieving them. These characteristics are: (1) sufficient transmission capacity to permit cross-border electricity trade; (2) coordination of transmission planning and investment; (3) integration of system and transmission operations; (4) creation of regional regulatory institutions with jurisdiction over the entire market; and (5) development of a single regional spot and futures market (Pierce, et al., 216). The authors assess the state of electricity market integration in the United States, the European Union, the Nordic countries, Australia, and Canada, based on these five characteristics. Their assessments are that: the Nordic countries are taking the

final steps to complete the process of market integration. Australia has strong regulatory and commercial integration, but lacks adequate coordination for transmission planning. The EU seems to lack the political will to create the preconditions for a competitive regional market. The US has varying degrees of market integration depending on region, while Canada has in place the preconditions for a regional market, but should increase integration within its borders as well as across borders with the US.

Pineau, Hira, and Froschauer (2004) propose a framework for measuring electricity sector integration, by analyzing three different indicators: infrastructural, regulatory, and commercial integration. They apply this framework to compare the level of integration between the Nordic countries, MERCOSUR, and NAFTA, which were selected as case studies due to their different stages of integration. In their comparative assessment, the authors conclude that the Nordic countries exhibit a high level of infrastructural integration, whereas this varies extensively across countries in MERCOSUR and NAFTA. In addition, countries in the three case studies surveyed are reluctant to create common institutions. Where this exists (under the Nordel framework), the cross-border institution has no executive power. The study also draws parallels between infrastructural and commercial integration – they assess that the Nordic countries are also much more advanced in terms of commercial integration as they are in infrastructural integration, compared with MERCOSUR and NAFTA. Finally, the study identifies factors that are key to influencing the integration process, which include the complementarity of generation feedstocks, the availability of physical infrastructure, domestic macroeconomic stability, as well as underlying norms, principles, and history of regional cooperation.

In their report to the Regional Electricity Regulators' Association (RERA) and the World Bank, *International Experience with Cross-border Power Trading*, **Castalia Strategic Advisors (2009)** proposes lessons for the Southern Africa's power integration project, based on a review of regional power sector integration in Central America, West Africa, North America, and the Greater Mekong Sub-region. The report focuses on the institutional mechanisms for increasing the investment prospects of regional grid capacity. Their main findings for the World Bank project include: the need for the regional market to explicitly address national concerns over security of electricity supply, the need for regional entities to be empowered in decision-making, as well as the crucial nature of having clarity in terms of the process and substance of regulation.

Hans-Arild Bredesen (2016) studies the Nord Pool model in terms of its inception, historical development, and market structure, in order to derive key success factors and pre-conditions to power market integration that could benefit similar projects in emerging markets. The report also considers how the Nordic model was adapted for the SAPP. The key findings are that national markets do not have to be deregulated in order for a market model for power trading to develop; that market regulation is good for market development; and that data transparency is one of the crucial factors that has determined the success of the Nord Pool.

Christian Egenhofer and Fabio Genoese (2016) take stock of the European Union's electricity market integration process, outlining the political and commercial arrangements of the market based on its historical development. They conclude that the regulatory harmonization in the EU is strong, but the market has developed relatively slowly due to physical infrastructure constraints.

Anoop Singh, Tooraj Jamasb, Rabindra Nepal and Michael Toman (2015) examine the progress of electricity market integration in South Asia to date in their report to the World Bank. They assess that the South Asian region has been slow in expanding electricity cooperation. Their main findings are that deeper electricity market reforms are not necessary for developing cross-border electricity trade, but that regional and domestic barriers have limited the scope of the regional market.

The **US DOE (2017)** published the second installment of its quadrennial energy review, based on ideas and advice gathered through an integrated outreach strategy that involved engaging different levels of government, the private sector, non-governmental organizations, consumers, universities, National laboratories, and other stakeholders. The chapter focused on energy integration in North America (Chapter VI) examines the historical development and current state of power sector integration between the US, Canada and Mexico. Based on this, the report proposes policy recommendations to improve regulatory coordination and cross-border integration.

S.K Ray and Guarav Jain (2016)'s report is a summary of their findings from their 2015 study tour to the Nord Pool, as part of a USAID project to develop the cross-border power market in South Asia. The study tour looked at the operational, institutional, and commercial aspects of the Nord Pool, and sought to understand its development strategy, challenges

and constraints faced during the implementation stage, as well as the role of stakeholders such as governments, regulators, utilities, and market players. The report concludes with a list of key lessons learnt, which include the need for a strong political mandate, regional planning, regulatory and dispatch coordination, and the apportioning of transmission loss pricing.

The **World Bank Energy Sector Management Assistance Program (2010)** draws from the experiences of regional power sector integration projects around the world, to present findings on how they addressed key aspects of the integration process. In the first phase of this project, Economic Consulting Associates was tasked to research different case studies on power integration projects around the world, without imposing any analytical framework on the information gathered. The second phase of this project synthesized the initial research on a global scale, summarizing key lessons. The broad conclusion reached was that there is no "one size fits all" solution to regional power integration – the approach must be adapted to local realities, and should leave room for flexibility. Other key findings were that competitive power markets are not a prerequisite for regional integration, and that market and institutional design can help to accommodate countries with different levels of sector liberalization. However, to achieve deeper levels of integration, power markets should be at similar stages of reform. In addition, regional institutions are crucial for regional power sector integration, but there is no one specific institutional structure that must be used.

2. Assessment of Regional Electricity Trading Systems

Nordic Countries (Nord Pool)

The Nord Pool is unanimously considered to be the most successful regional power exchange that exists today. While Oseni and Pollitt (2014) do not include the Nord Pool model as part of their case studies, they state that it is the most successful power market model in the world. The high level of integration is seen from the fact that the volume of electricity traded on the Nord Pool Spot in 2013 was 88% of Nordic consumption (Ray and Jain, 2016). The physical infrastructure is also relatively well-developed. Even as early as 2000, cross-border transmission capacity was between 10 - 31% of domestic electricity production capacity for the countries in Nordel (Pineau, et al., 2004).

Bredesen (2016) explains that the inception of the Nord Pool model was caused by over-investment – and hence, overcapacity – of hydropower production in Norway. The realization of market distortions that led to over-investment created a push for domestic power sector liberalization, while the overproduction of power was the catalyst for the opening up of electricity trade with Sweden.

Today, the Nord Pool spot trading region covers the Nordic and Baltic states, and is in the process of being integrated with adjacent regional markets as part of the vision to create a pan-Europe electricity market. According to Ray and Jain (2016), there is strong regulatory coordination between the Nord Pool countries: NordREG was created as the forum for the national regulators to cooperate on a regional level. In addition, the TSOs of the Nordic and Baltic countries jointly own Nord Pool Spot AS, which provides a reference price and acts as a "neutral and reliable power-contract counterparty to market participants" (Ray and Jain, 2016). Apart from these operations, the TSOs also cooperate in long-term market development from a regional perspective, to ensure the security of electricity supply.

The commercial arrangements of the Nord Pool are highly advanced. Nord Pool Spot operates both physical and financial markets. Physical trades are conducted through the day-ahead market and intra-day markets, while commodity derivatives are traded on the UK N2EX power market.

Southern Africa Power Pool (SAPP)

Bredesen (2016) considers the SAPP to be the most advanced power pool in Africa. In terms of regulatory structure, the SAPP is modeled after the Nord Pool, in that it ensures equal rights and obligations for all participating utilities. The SAPP has also achieved commercial integration with the setting up of a Day Ahead Market (DAM) in 2009, although only 6% of energy demand in the DAM was traded (Oseni and Pollit, 2014). Other market mechanisms include the forward physical market, as well as the intra-day market (Bredesen, 2016). The market underwent two phases of development: the infrastructure was first developed based on long-term bilateral deals, before surplus generation capacity was available for short-term "opportunity trading" in recent years (Castalia, 2009).

Despite the relatively mature operational procedures, the main barrier to market development in the SAPP has been its transmission interconnector constraints, in the face of

rising electricity demand (Oseni and Pollit, 2014 & Castalia, 2009). The World Bank (2010) also points out that the harmonization of rules, regulations and grid codes in the SAPP is lacking.

Western Africa Power Pool (WAPP)

WAPP is assessed to have made slow progress in terms of market integration – there has been almost no regional trading activity after over a decade. In contrast to the deeper integration achieved by the SAPP, the limited capacity of existing infrastructure has served as a significant constraint for market integration (Oseni and Pollit, 2014). However, Castalia Strategic Partners (2009) argues that in terms of its decision-making framework, the WAPP secretariat is more empowered than that of the SAPP, and hence, is able to speed up the process of implementation for priority projects. This observation was made at a time when the SAPP was struggling to agree on a power pool plan. However, the SAPP has since launched its Day Ahead market mechanism in 2009.

Mercado Regional de Electricidad (MER) – Central America

MER, which came into force in 1999, is an example of cross-border cooperation in a region where there is a huge range in terms of the level of domestic market liberalization (Oseni and Pollit, 2014). The Central America region is characterized by a significant electricity supply deficit (Fedosova, 2015). Hence, the MER was initiated to decrease the costs of generation by reaping economies of scale (Oseni and Pollit, 2014). The MER has been successful in the creation of a seventh, regional market that is independent from the six pre-existing national markets in the region. However, the World Bank (2010) assesses that this has been a slow process, taking 23 years since the project's feasibility study.

The SIEPAC line project, which connects all six Central American countries, has significantly improved the infrastructural integration of the region's electricity markets (Fedosova, 2015). There is also a relatively high level of regulatory integration in MER. One of the first steps of the MER was to establish a regional regulator, a regional system operator and a transmission owner (Castalia, 2009). In essence, the regional market was superimposed over the other six national markets (Oseni and Pollit, 2014). There is a high degree of institutional harmonization, as national regulators coordinate common market rules and implement MER codes, which determine the regulatory frameworks for national system operators

concerning dispatch, tariffs and transmission services (Fedosova, 2015). In addition, the MER also has in place a dispute resolution mechanism for market players (Castalia, 2009).

Commercial integration has been achieved through day ahead markets, a real-time balancing market, and capacity auctions (IEA, 2016). However, trading is still predominantly conducted on a bilateral basis, with less than 5% of electricity consumption conducted through the regional power market. (Oseni and Pollit, 2014). The regional market operator gathers pre-dispatch information from national market operators in order to set nodal prices for trading. There is a pricing mechanism also in place for countries such as Honduras and Costa Rica, which have no competitive national electricity prices (Fedosova, 2015).

There exist challenges to the further development of the regional power market. The region is characterized by the prevalence of subsidies and price controls, which distort the market (Fedosova, 2015). In addition, the aging generation fleet and transmission infrastructure of the region will have to be addressed before further development of a power market can occur (IEA, 2016).

North America

North America is a relatively complex market, as regional trading exists on both a national as well as an international level. Cross-border power trade between the US and Canada is at an advanced stage, in terms of available infrastructure as well as institutional arrangements. In fact, the US Department of Energy (2017) reports that North-South integration between the US and Canada surpasses East-West power trading between different states or ISO/RTOs within each of the countries. This is helped by the fact that investment decisions in North America also enjoy more regulatory certainty (Castalia, 2009). However, cross-border transmission between the US and Canada are already at full capacity, which poses a barrier to the deepening of integration. What is also interesting in North America is that “cross-border coordination is sometimes greater than subregional coordination within a specific country.” (DOE, 2017)

There is much less power market integration between the US and Mexico. Transmission connections between ERCOT and Mexico are asynchronous, while there is a lack of domestic, long-distance transmission infrastructure in Mexico to enable California to connect with the Mexico’s Federal grid through Baja California (DOE, 2017). Mexico is

currently undergoing domestic power market liberalization, which has included the operationalization of a domestic wholesale power market in 2016. This will ease cross-border coordination for electricity trading. However, the DOE's report also points out that states along both sides of the border continue to face power supply reliability issues, which has been an impediment to cross-border trade.

Within the US, PJM is considered by Oseni and Pollitt (2014) to be the most mature interstate electricity trading area. Its transmission grid covers the widest area out of the US ISO/RTOs. In terms of regulatory arrangements, the ISO (a non-profit entity owned by its members) operates both physical and financial electricity markets. It is important in ensuring open access to the grid, as well as market transparency (Oseni and Pollitt, 2014). PJM is also subject to federal regulation by the Federal Energy Regulatory Commission (FERC). The power pool's market mechanisms are well-developed, utilizing day-ahead and real-time markets, as well as transmission auctions. However, the World Bank (2010) points out that its pricing mechanism (locational marginal pricing) does not provide the necessary returns to spur investments in congestion reduction.

Despite the relatively high levels of market integration within the respective US interconnections, there is relatively limited transmission capacity between them – almost negligible compared to the interconnection capacities within them. The main challenge has been that these interconnections cut across multiple system operation jurisdictions. However, efforts are being made to increase the level of coordination between ISO/RTOs. At the direction of FERC, PJM and MISO have engaged in a *joint operation agreement* since 2008, while ISO-NE, NYISO, and PJM have also engaged in the *Northeast ISO/RTO Planning Coordination Protocol* since 2004. FERC Order 1000 also requires regional planning authorities to exchange data annually, as well as harmonize their decision-making processes (Baritaud and Volk, 2014).

European Union

There are multiple regional electricity trading blocs that exist within the EU, which are: the Nordic region including the Baltic republics, Northwestern and Central Europe, the Iberian Island, and Southeast Europe (Egenhofer and Genoese, 2016). The objectives of regional power sector integration are to lower costs through increasing competition, as well as to increase the security and stability of supply. The creation of an internal EU market was also

seen as a tool for achieving European integration (Egenhofer and Genoese, 2016). Overall, Europe has been relatively successful at creating a large area synchronous frequency grid (Baritaud and Volk, 2014). However, Egenhofer and Genoese (2016) state that the market has been "slow to take off". They believe that this is mainly due to the lack of sufficient interconnection capacity linking member states, leading to fragmentation of the market.

However, there has been strong cross-border regulation for the EU; in fact, electricity market integration is legally mandated by the EU. Egenhofer and Genoese (2016) state that regional power sector integration in Europe has evolved based on three EU directives: The first electricity directive (1996) and the 1998 gas directive concentrated on full market liberalization through the unbundling of integrated companies, as well as the promulgation of rules mandating non-discriminatory access to the grid. Each power generator was also allowed to choose its own supplier. The "Third Package", which entered into force in 2011, focused on improving cooperation between member countries on both system operator and regulator levels; the independent Agency for the Cooperation of Energy Regulators (ACER) and the European Networks of Transmission Systems Operators – Electricity (ENTSO-E) were both created to address the problem of power networks being developed primarily based on national member states' interests.

As seen from these EU directives, the EU has the supra-national authority to mandate domestic market reforms. In addition, the EU also has strong enforcement mechanisms; the European Commission has the power to bring countries to court within four months if they fail to implement EU legislation, and can also act without member states' consent in the field of competition law (Egenhofer and Genoese, 2016).

In terms of the commercial market structure, the EU is an energy-only market, with no pricing mechanisms for capacity availability. The authors assess that the EU has been successful at implementing market-coupling for the day-ahead markets, but not for the intra-day and power-balancing markets (Egenhofer and Genoese, 2016).

Fedosova (2015) analyzes the EPEX Spot market, which encompasses the Central Western Europe countries. Like in Central America, the Central Western Europe countries also exhibit a high level of diversity in terms of the organization of domestic power markets, as well as the level of market liberalization. Infrastructural integration within the EPEX Spot zone is assessed to be high, but varies depending on borders. There are ongoing transmission

infrastructure projects to eliminate bottlenecks in power trading; according to Fedosova (2015), the responsibility and costs are "divided between countries according to the territory of lines and transformers' location" (Fedosova, 786). In terms of regulatory integration, the EPEX Spot benefits from the common rules under EU regulation, which mandates open access of the transmission grid. The commercial arrangements of the EPEX Spot exchange are relatively advanced, as the exchange optimizes cross-border exchanges via market coupling mechanisms. Trading can be done on both spot and futures markets.

Oseni and Pollit (2014) study two smaller regional grids within the EU – the Single Electricity Market (SEM) and the Energy Community of South East Europe (ECSEE). The SEM spans two countries (Northern Ireland and the Republic of Ireland), and is assessed to be running efficiently. The power pool operates a wholesale market, and constantly monitors bidding behavior to prevent gaming. In addition, the SEM was the first power pool spanning more than one jurisdiction that did not use a single currency.

The ECSEE has recently embarked on electricity market integration (since 2005). They have achieved some success in terms of institutional integration, such as the implementation of an inter-TSO compensation mechanism for cross-border power trade. However, the market lacks a regionally coordinated capacity allocation and congestion management system, which poses a barrier to cross-border electricity trade and further integration. As of 2010, traded electricity accounted for 14% of power consumption in Southeast Europe (World Bank, 2010).

National Electricity Market (NEM) – Australia

The NEM has a high degree of regulatory integration, but suffers from a lack of interstate transmission capacity. The NEM operates under the rules of the National Electricity Code, which mandates non-discriminatory access to transmission. Generators larger than 30 MW are also required to participate in the NEM. The code is enforced by the National Electricity Code Administrator, while the National Electricity Market Management Company (NEMMCO) was created to operate the market. The commercial arrangements of the NEM are well-developed, with an intra-day market trading in half-hour blocs, as well as financial spot and futures contracts traded on the Sydney Futures Exchange. However, the lack of transmission capacity has had the effect of "regionalizing" the grid by limiting the amount of power trade between states (Pierce et al., 2007).

South Asia

The South Asia region had a relatively late start to political cooperation on region-wide electricity market integration, with the framework agreement promulgated only recently in 2014. The agreement calls for the establishment of a regional market for electricity, which would include "nondiscriminatory access to transmission, market-based pricing of electricity exchanged, and establishment of a body for coordinating regional power integration and trade." However, little progress has been made on this. The present mechanism for cross-border power connections are through bilateral agreements, primarily between Nepal-India, India-Bhutan and India-Bangladesh. These tend mostly to be government-government relationships, with little involvement of the private sector (Singh, et al., 2015).

Singh, et al. (2015) explains the regional and domestic barriers to wide area power market integration. On a regional level, there is little political will for electricity cooperation due to a lack of mutual trust stemming from historical animosities. In addition, the government-to-government model of advancing power market cooperation incurs high transaction costs, due to lengthy political and technical negotiations. Second, the authors mention that there is currently no platform for cross-border regulatory coordination. Third, tariff and non-tariff barriers to electricity trade continue to prevent a deepening of integration; different taxes are imposed for export, import, and transit of electricity, while India's electricity import licensing restrictions limit market participation.

On a domestic level, countries in the SAR are at varying degrees of vertical unbundling and market liberalization. The Single Buyer Model continues to dominate wholesale generation market across the region (except for India's Day Ahead Market). While most SAR countries are currently engaging in power sector reform, Singh et al. assess the process to be relatively slow, and entwined with politics. There is insufficient investment in generation and transmission capacity, as market distortions (such as price subsidies) reduce the returns and incentives for investment. Against the prospects of low returns, the risk is relatively high, as domestic partnering firms tend to have weak financial conditions, and may not be able to deliver high service standards. In addition, inefficient domestic regulatory institutions, and the lack of institutional capacity for data collection and effective market management all act as further barriers to cross-border coordination (Singh, et al., 2015).

Greater Mekong Sub-region (GMS) – Southeast Asia

The GMS power integration project aims to develop power interconnections to improve regional electricity trade, as a means for achieving economic growth in the region. It had very clear phasing of project stages, starting from a focus on bilateral export projects, to increasing power trade between pairs of GMS countries, to providing third party access for these interconnections, before finally creating an integrated and competitive regional power market. There is no permanent regional-level institution that oversees the project, but multiple working groups consisting of national regulatory agencies meet for cross-border coordination. While the GMS has been able to achieve bilateral power trade, this is limited to 1% of the region's power consumption. In addition, the development of a regional market is still in its conceptual stage (World Bank, 2010).

3. Findings from the academic literature

By comparing different regional power interconnections, the academic literature highlights the key success factors for deepening electricity market integration. Some of these factors are deemed necessary for the functioning of power markets; others are not, but are seen as preferable.

One size does not fit all. In terms of regional power integration strategies, regulatory structures, commercial mechanisms and institutional arrangements, the World Bank (2010) concludes that there is no one model that should be applied. Hence, the report emphasizes the need to adapt to local circumstances continuously, by conducting reassessments throughout the integration process. Flexibility is also required because objectives (and hence, the focus) of power market integration may change over time. The World Bank cites the case of Europe, where a major shutdown of the synchronous system stemming from a disturbance in Italy in 2003 led to the adoption of a legally enforceable multilateral agreement. Special regional power cooperation arrangements were also made in the SAPP to ensure the security of power supply during the South Africa World Cup in 2010, against the backdrop of a serious lack of adequate reserves causing region-wide blackouts and load shedding (World Bank, 2010).

Institutional Design. The current literature suggests that institutional design is important in determining both the level of integration, as well as the impact of such integration. The importance of market design in addressing national concerns of electricity security is crucial

in terms of ensuring a sustained level of political will to deepen integration. Oseni and Pollitt (2014) argue that with greater integration, some countries become more reliant on imports of electricity, which may cause the closure of domestic facilities, thus, increasing electricity dependence. They assess this risk to be manageable, and state that the exporting country is also equally dependent on electricity trade for export revenues. This risk is also very pertinent for developed countries – the US DOE (2017) identifies that one of the largest barriers to US-Canada power trading is the concern that cost-effective Canadian hydropower would give Canadian suppliers greater market power over US generators.

Political Commitment to Free Trade. Egenhofer and Genoese (2016) state that "agreement among governments on the long-term objective to establish a market" should be the first lesson drawn from the European Union case. In the case of South Asia, Singh, et al. (2015) also argue that the lack of political will to drive integration is one of the main barriers that explains the slow process of market integration in the region. A broader political commitment to free trade is also important, as it leads to a deepening of the trust needed to develop a regional power pool. Oseni and Pollitt (2014) point out that most of the power market integration projects exist within the context of a regional economic community. In addition, out of all their selected case studies, the authors argue that ECSEE is the least institutionally developed because it does not lie fully within the EU free trade zone. Castalia Strategic Partners (2009) takes this one step further, proposing that such political goodwill should be codified into a binding commitment through a treaty or protocol that has the force of law in each ratifying country. Hence, one of Castalia's recommendations to the SAPP is the adoption of protocols along the lines of the WAPP and the MER, as it would lead to greater regulatory certainty for power trading. The World Bank (2010) supports this view, stating that the formal endorsement or signing of regional power investment plans by Heads of State creates visibility of the political buy-in, which increases the chances of success.

Bredesen (2016) points out that one important aspect of political trust between the countries engaged in regional power trading is transparency, which has remained central to the success of Nord Pool. Equal access for all market players to relevant price-sensitive information or market developments is mandated by the Nord Pool's reporting requirements, which has since been adopted by the EU.

Cross-border Regulation. Oseni and Pollit (2014) state that a cross border regulatory agency is not necessary, but that some regulatory oversight is beneficial. The case of SAPP shows that a power pool can exist without the creation of a cross-border regulator, but the authors point out that it may have prevented Eskom's predatory pricing behavior. The Nordic model has also been successful in creating an integrated regional electricity market through a decentralized framework, whereby "each country has kept all its legislative sovereignty and no common institution has been created." (Pineau, et al., 2004). In addition, Bredesen (2016) explains that the TSOs should share an equal position within the context of the regional power trading framework. Hence, the respective TSOs should be co-owners, which has been the working model for Nord Pool's expansion of its membership. This ensures that market activities are driven by regional planning. While the World Bank (2010) argues that harmonization is not a precondition of regional power market integration, their report states that there must eventually be a uniform regional regulatory approach to facilitate the deepening of regional integration. This could come in the form of a cross-border regulatory authority with discretionary powers, or through the adoption of a common regional regulatory framework.

Singh, et al. (2015) argue that a minimum degree of regulatory harmonization must be in place in order for the regional market to move beyond bilateral transactions. This should include open and nondiscriminatory access to transmission capacity, as well as mechanisms for congestion management and transmission pricing. Hence, the authors attribute the slow integration of the South Asia region to the absence of a regional body with the resources and influence to implement these regulations.

Market Consolidation and Market Coordination. In general, academics are also cognizant of the fact that the degree of institutional integration tend to be lower in cross-border markets than within a single national boundary. The US PJM is considered to be one of the most developed power markets, due to the regulatory oversight of the FERC (Oseni and Pollit, 2014). However, this is much more difficult to achieve when multiple governments are involved, as there is a general fear of the loss of national sovereignty over a politically sensitive sector (Pierce, et al., 2007).

Hence, Baritaud and Volk (2014) propose two different models for power market integration – market consolidation and market coordination. They argue that consolidation is more

efficient, as the merging of system operators ensures common market rules are applied for all areas and players. However, they observe that this has only been possible for intra-country markets, such as the NEM (Australia), PJM (USA), and MISO (USA). For market integration in cross-border power trading, coordination between system operators – through defining cross-border transmission capacity allocation as well as ensuring efficient border price formation – seems to be a viable model.

The Nord Pool actually goes one step further in terms of ensuring adequate coordination between power sectors. When Finland was looking to join Sweden and Norway in power trading, Stattnet (Norway) and Svenska Kraftnät (Sweden) required that the Finnish power sector should have the same structure as Norway and Sweden by unbundling ownership of the grid and of production (Bredesen, 2016).

The World Bank (2010) does not propose a specific model for regional cooperation or coordination, but points out that the establishment of regional institutions are necessary to sustain progress in power integration projects. These could come in the form of private sector arrangements, or regional bodies commissioned by the national governments. However, the report emphasizes that these institutions need to be flexible and to evolve based on the changing political realities.

Domestic Market Liberalization. There is some disagreement among academics as to whether the national market situation must be addressed first, before engaging in international electricity trading. Oseni and Pollit (2014) state that in regions with a history of domestic energy subsidies, cross-border integration would, in fact, worsen these market distortions, and in effect decrease overall welfare. However, the case study of the MER shows that this is not true. As mentioned above, Honduras and Costa Rica, do not have competitive domestic electricity prices, but the MER is still able to put in place a mechanism for border pricing for power trades (Fedosova, 2015).

Liberalization through vertical unbundling of the domestic power industry is also not a pre-requisite of cross-border power trading. Within the Nordic, European, and Central American power markets, competition within the wholesale spot markets was not hindered by the presence of vertically-integrated companies in some countries (Pineau, et al., 2004 & Fedosova, 2015). Bredesen (2016) also points out that full market liberalization from the start is not a prerequisite for market integration, and that liberalization should be a gradual,

stepwise process. He cites the case of the SAPP, where the market is functioning even though some domestic markets are still structured based on single buyer or seller models.

However, Bredesen does concede that the unbundling of domestic power markets was crucial to the success of the Nordic regional market. He states that all the Nordic member countries followed the same process of unbundling and had similar market structures, which explains why integration into the Nord Pool market was relatively easy. Bredesen's view is echoed by the World Bank (2010), which argues that competitive domestic markets are not a pre-requisite for regional power sector integration, but that deeper levels of integration can only be achieved if the respective national markets are at similar stages of reform. Singh, et al. (2015) suggests that the logic may work in the opposite direction – developing regional electricity trade may conversely help to improve competition in domestic markets, and bolster domestic industry reforms.

Open access to transmission lines. While full domestic liberalization of the domestic power sector is not required for regional electricity market integration, power trades cannot occur without open access to cross-border transmission infrastructure. EU regulation ensures non-discriminatory access to the regional grid, while the ISO/RTOs within the US regional power markets have the responsibility to enforce this (Oseni and Pollit, 2014). The regional grid company in Central America was also created to ensure open access to the SIEPAC line (Fedosova, 2015).

Market Trading Mechanisms. Some of the literature also suggest that the creation of a wholesale spot electricity market is a pre-requisite for electricity market integration (Pierce, et al., 2007). However, the WAPP model indicates that it is possible for spot trading to evolve as the market develops from long-term contracts and the allocation of excess production (Oseni and Pollitt, 2014).

Transmission Capacity. Insufficient cross-border transmission capacity is a significant barrier to market integration, as it creates a bottleneck to power flows (Baritaud and Volk, 2014). Oseni and Pollitt (2014) compare the development of the SAPP and the WAPP, suggesting that the WAPP's relatively slow progress beyond bilateral trading is due to a lack of transmission capacity. This view is shared by Castalia Strategic Advisors (2009). Considering the case studies of MER and SAPP, Oseni and Pollitt also conclude that the lack of

transmission capacity has not prevented the emergence of spot markets, but severely limits their significance and explains the prolonged dominance of bilateral trading.

Investments in Future Infrastructure. Given the importance of transmission and grid capacity in facilitating market integration, the regional power pool should also incentivize investments in capacity expansion. The literature identifies some ways in which institutional arrangements may hinder such investments instead. In some cases, such as the SAPP, the uncertainty of revenue flows associated with short-term trading may prevent investments in new infrastructure (Castalia, 2009). In addition, Baritaud and Volk (2014) argue that the lack of agreed-upon cost allocation methodologies can hinder investment Hence, they suggest that the cost allocation of new transmission lines should reflect the benefits.

Institutional partners. International development banks and institutions are important in the development of regional power market infrastructure, especially due to the high capital costs. Oseni and Pollitt (2014) state that all of the regional models that they studied have been financed by international development agencies (IADB, World Bank and AfDB). The EU has also financially supported interconnection projects in the SEM and ECSEE. Apart from financial support, multilateral agencies have also been involved in the creation or shaping of regional institutions (World Bank, 2010).

Process of Regional Market Integration. Creating a regional power market starting from just two or three market players has seemed to be a successful model. Oseni and Pollit (2014) propose that starting small means that the benefits of trade can be demonstrated, and that new parties would be joining an existing arrangement that works. Their case studies also show that PJM began with just three utilities, while the SEM started with two countries before embarking on integration into the wider Great Britain market. In addition, they suggest that the WAPP's slow development could be due to the large number of participating countries right from the start. The EU has also utilized this model for its market integration project, by adopting a "regional markets" approach – the development of four regional markets are seen as stepping stones to creating an EU-wide power market (Egenhofer and Genoese, 2016).

Singh, et al. (2015) propose a similar approach to regional power market integration. They suggest the deepening of market integration can be done in three phases. First, a focus on increasing bilateral trade will enable expansion of interconnections, and the adoption of

simple operation rules for cross-border power trade. In the medium term, implementing three-country arrangements for electricity trading can help to harmonize access rules and transmission fees, and may facilitate granting other member countries access to India's short term power markets. This process of gradual harmonization will then have long-term benefits for regional market integration.

The World Bank (2010) explains the general development process of competitive regional markets: regional electricity cooperation tends to begin with the building of transmission interconnectors based on long-term power purchase agreements. The expansion of physical infrastructure enables more countries to join the network. Then, short-term trading starts to emerge based on arbitrage opportunities stemming from the different domestic load profiles and cost structures across the region. As confidence in the market grows, competitive market frameworks are developed, together with regulatory harmonization.

Bredesen (2016) also suggests that patience is required in market formation. Market players ultimately need to decide between utilizing long-term bilateral contracts or the new market mechanisms, based on their assessment of the risk. He proposes that trust in the market takes time to build; market liquidity will grow. In fact, Singh, et al. (2015) argue that regional electricity market integration "typically evolves in the wake of bilateral cross-border electricity trade arrangements."

Useful Frameworks

The existing literature on regional power market integration also provides useful frameworks for assessing regional electricity markets, in terms of defining the characteristics of an integrated regional electricity market, as well as listing the criteria for assessing the degree of market integration.

Pierce, et al. (2007) identifies five characteristics of a fully integrated regional electricity market:

- Existence of adequate cross-border transmission capacity;
- Coordination of transmission planning and investment;
- Integration of system and transmission operations;
- Creation of regional regulatory institutions with jurisdiction over the entire market; and

- Development of a single regional spot and futures market.

In addition, Fedosova (2015) provides a framework for assessing the level of electricity market integration:

A. Infrastructural integration:

- Existing cross-border transmission capabilities
- Countries' shares in cross-border electricity exchange
- Planned new electric lines projects (allocation of costs and responsibility between countries).

B. Regulatory integration:

- Means and degree of coordination between National Regulatory Bodies
- Sub-national regulatory bodies and their roles, if there are any
- National electricity market models convergence.

C. Commercial integration:

- Electricity cross-border trade volumes, in particular, electricity import and export statistics
- Shares of imported and exported electricity in internal production and consumption
- Price coordination level.

While most of the literature analyzes the three aspects of integration separately, Pineau et al. (2004) explain how these three dimensions are complementary: Both commercial investment in as well as operational management of physical infrastructure requires harmonized regulatory standards between jurisdictions.

VITA

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